COMBAT RATION ADVANCED MANUFACTURING TECHNOLOGY DEMONSTRATION (CRAMTD)

"Filling Systems"

Short Term Project (STP) #2

FINAL TECHNICAL REPORT
Results and Accomplishments December 1990 through April 1994)
Report No. CRAMTD STP #2 - FTR 8.0
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June 1995

CRAMTD CONTRACT NO. DLA900-88-D-0383
CLIN 0003

Sponsored by:
DEFENSE LOGISTICS AGENCY
Cameron Station
Alexandria, VA 22304-6145

Contractor:
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THE CENTER FOR ADVANCED FOOD TECHNOLOGY*
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*A New Jersey Commission on Science and Technology Center

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13. ABSTRACT (Maximum 200 words)

The Project objective was the design, fabrication and evaluation of food ingredient filling systems for rigid and flexible containers including Tray Pack Cans and MRE Pouches. These systems were designed for a wide range of products at the demonstration site using the existing powered conveyor/seamer and the horizontal form/fill/seal lines. Ingredients and filling machines were classified into four categories: Liquids (pumpables), Placeables (robotics), Meat (solids - high value) and Vegetables (solids - lower value). An electronically controlled rotary pump filler from Oden was modified to a 3 head/6 nozzle design producing substantial cost savings while maintaining all performance requirements. An Adept PackOne Robot was integrated with a EwingGear machine vision system to provide item acquisition, orientation and size conformance. The meat filler (Solbern Tumble Filler) and Vegetable filler (FEMC Volumetric Filler) were integrated by Solbern to include novel variable volume Transfer Cups for either MRE Pouches or Tray Pack Cans. A Non-traditional Capital Investment Criteria analysis was conducted on the meat filling system concluding that the proposed system promised significant savings.

14. SUBJECT TERMS

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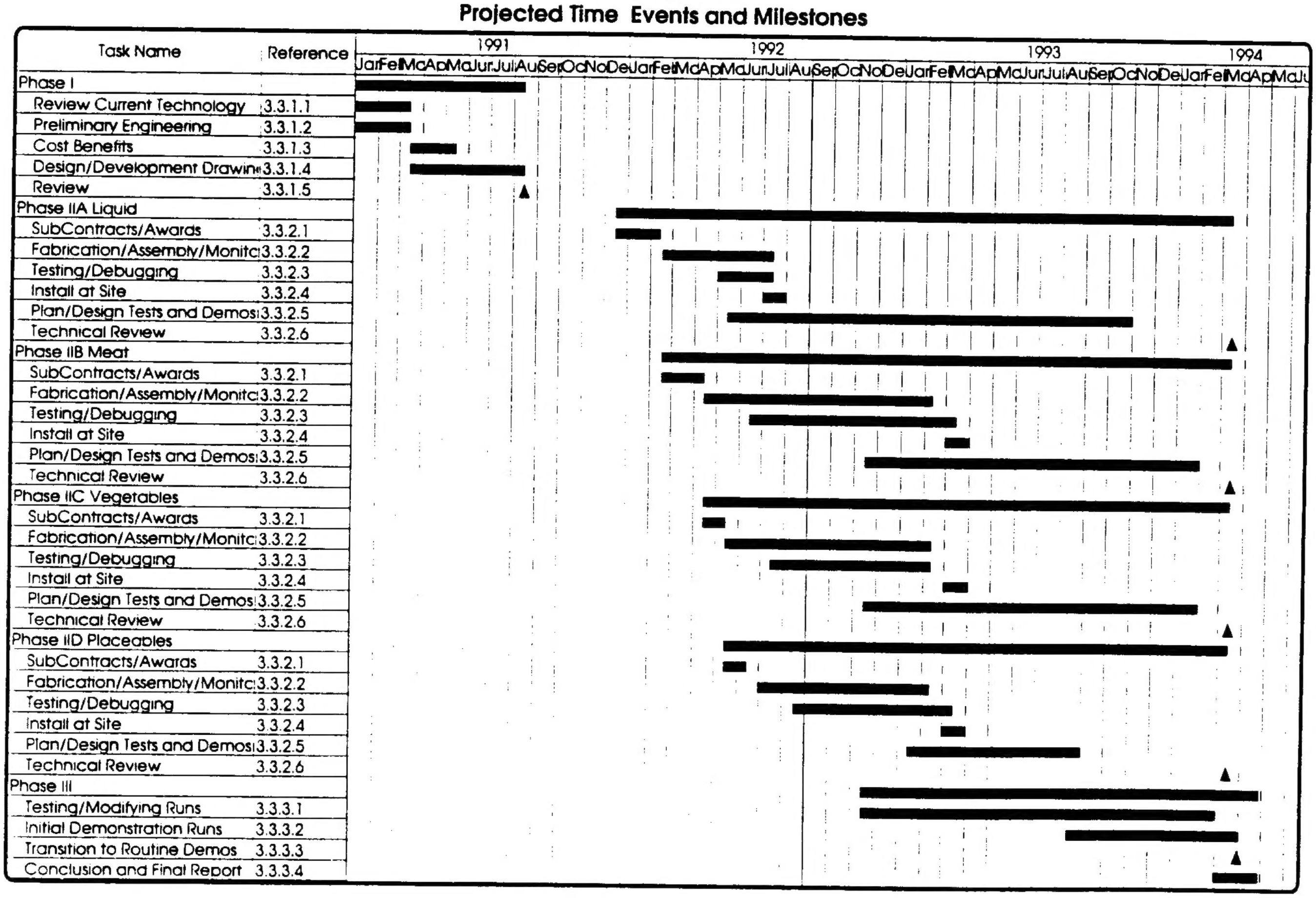
TABLE OF CONTENTS

1.0 CRAMTD STP#2

1.1 Introduction and Background

STP#2 implementation was begun December 14, 1990 based on the several proposal revisions submitted with the last proposal approved on August 17, 1990. The overall STP objective is to evaluate, design, develop and fabricate multiple prototype product filling systems for rigid and flexible container including MRE Pouches and Tray Pack Cans. These ingredient filling systems will be designed to fill a wide range of products in the demonstration site using the existing powered conveyor/seamer line and the horizontal form/fill/seal machine. Controls will be designed wherever possible for integration into an advanced computer control system within the CRAMTD process automation Computer Integrated Manufacturing (CIM) strategy. The program was managed according to the schedule in Figure 1.

Fig 1 - CRAMTD Short Term Project #2
Filling Systems
Projected Time Events and Milestones



1.2 Progress Summary

- The STP was started in December 1990.
- A review of current filling technologies was made.
- Tests were made on a loaned liquid pump type filling machine with excellent results.
- Visits were made to several filling equipment manufacturers to review their equipment.
- As a result of visits, input from tests and information obtained from our review of current technologies and requirements, drawings and specifications were prepared and reviewed by management.
- Requests for quotation were sent to the following companies for liquid filling:
  - Oden Corporation
  - Hi-Bar
  - Modular Packaging
  - Hinds-Bock
  - Auto-Prod
  - Raque Food Systems
  - FEMC
- A Pre-Bid Conference was held and the vendors were evaluated on the following criteria: delivery, cost, performance, engineering features, service and training. Oden Corporation was selected.
- Requests for quotation were sent to the following companies for volumetric filling of meat:
  - Per-Fil Industries
  - FEMC
  - Solbern
  - HEMA, USA
  - Spee-Dee Packaging Machinery
  - Raque Food Systems
  - Mateer Burt
- A Pre-Bid Conference was held and the vendors were evaluated on the same criteria as the liquid filling machine. Solbern was selected.

- Requests for quotation were sent to the following companies for volumetric filling of vegetables:
  - Solbern
  - FEMC
  - Raque Food Systems
  - Spee-Dee Packaging Machinery
- A Pre-Bid Conference was held and the vendors were evaluated with our same criteria as on all filling machines. FEMC was selected.
- An Adept Pack One Robot to handle placeables was ordered as a sole source. They were the only robot that was USDA approved.
- Requests for quotation were sent to the following companies for Integration (conveyor, gripper and vision system) of the Adept Robot.
  - EwingGear
  - Precision Automation
  - Gelzer Systems Company (Division of ATS)
  - TW Kutter
- A Pre-Bid Conference was held and vendors were evaluated with the same criteria as the previous selections. EwingGear was selected.
- The Oden Liquid Filler was installed
- The Solbern Transfer Filler was installed.
- The FEMC Rotary Volumetric Filler was installed.
- The Adept Robot for placing ham slices was installed.
- Tests were made on the filling machines and modifications made.
- FEMC installed a rotary funnel assembly that improves product placement in the Solbern Cup.
- Adept Robot conveyor was modified to improve the vision system.
- Filling accuracy tests were made on the Oden, Solbern and FEMC filling machines.
- Filling Equipment Demonstration Workshop held March 16, 1994.

1.3 Results

The Oden Filler (gravy), Solbern Filler (meat). FEMC Filler (vegetables) and Adept Robot (ham slices) were used successfully in all of our demonstration production runs.

The accuracies of the Filling Equipment expressed as standard deviation varied with each machine. The Oden Liquid Filler was the most accurate which was expected. Standard Deviation ranged from .26 to 1.04 oz.. with viscosities of 3,400 and 24,000 cp. (Appendix 4.5.4)

The Solbern Transfer Filler standard deviation ranged from 2.01 gm.for diced vegetables with a mean value of 59.77 gm and to 5.63 gm. for diced meat with a mean value of 75.03 gm. A Solbern customer tested the Filler with Oatmeal with a mean value of 337 gm and a standard deviation of 4.09 gm.. (Appendix 4.7.4). The Solbern Cup Dumper Assembly worked very well after some debugging. Initially product when very wet stayed on the cup bottom when inverted. This was corrected by knurling the bottom plastic piston.

The FEMC Volumetric Filler standard deviation varied from 1.47 gm. with a mean of 20.88 gm to 4.95 gm. with a mean value of 61.02 gm (Appendix 4.6.4).

The Adept PackOne Robot was able to pickup and place ham slices into the MRE pouch at rates up to 60 per minute (Appendix 4.8.4).

The Oden, Solbern and FEMC fillers were designed to have the greatest degree of flexibility possible. All machines are on castors and are moved to fill MRE pouches or Half Steam Table Trays. The filling machines provide for extreme filling equipment flexibility. The MRE line is indexing and requires low liquid fill volume from 1 to 8 ounces and filling 6 pouches per index while the Tray Pack line is continuous motion and the filling volume is as large as 106 ounces with a single fill.

1.4 Conclusions

The Solbern Transfer Filler can fill a wide range of products both frozen and thawed with

no change parts and only minor machine adjustments.

The Solbern Cup Dumper Assembly works well for multiple product fills per index on a Horizontal Form/Fill/Seal Machine. The transfer cups with the variable volume (movable piston) allows filling two products in the same cup with one cup dumping assembly. The first product (more costly) can be checkweighed and if out of specifications returned to the filler for refilling. (Appendix 4.3.1).

The FEMC Volumetric Filler can fill both thawed and frozen products without damaging them. However, the air blow off velocity and placement is critical for thawed product to prevent clinging to the inserts and funnels.

The Oden Liquid Pump Filler fills liquids such as gravy with excellent accuracy. The higher the viscosity and greater the volume the more accurate the fill.

The Adept PackOne Robot can be programmed relatively easy using Adept's MotionWare with pull-down menus and dialog boxes. Different grippers can easily be fastenned to the robot arm to pick up an unlimited variety of products. The vision system provides for inspection of area and size of the placeable item.

1.5 Recommendations

The Oden Liquid Pump Filler is recommended for gravies and other liquids. The use of a rotary pump gives a very wide range of filling volume. Products can be filled from a few milliliters to gallons. Due to the pump going in one direction it gives higher filling rates than the reciprocating piston filler. Also the electronically controlled Oden Filler permits the operator to accurately enter the settings for fill volume and flow rate for a particular product and these can be conveniently reentered for subsequent production runs.

The Solbern Transfer Filler is recommended to fill solid product such as cubed meat. This filler fills product into cups by product cascading into the cups as they move through the filler. Shaking the cups as they are being filled allows for a uniform density and therefore a more accurate fill. The cups are then transferred to a cup dumping assembly that is a separate unit designed specifically for the desired filling pattern. There are two of these assemblies, one for a single fill for the Tray Pack can and the other for a multiple fill for the MRE pouches on the

horizontal form/fill/seal machine. Like the Oden the Solbern filler is on castors and can be moved to either line.

The FEMC Rotary Volumetric Filler is recommended to fill solid product such as cubed vegetables. While the FEMC can fill thawed product it requires more machine setup than the Solbern filler due to the thawed product sticking to the inserts and funnels. The Filler uses telescoping inserts which by the use of a servomotor changes the volume (within a range). For larger volumes such as the Tray Pack can the inserts are changed.

For handling placeables for the MRE pouch the Adept PackOne Robot is recommended. This robot is USDA approved and is very flexible. Changeover to another filling operation and product is easily done by making a program change and changing the grippers.

2.0 PROGRAM MANAGEMENT

This STP has been proposed as a three phase work activity as illustrated on the "CRAMTD STP#2 Filling Systems -Projected Time & Events and Milestones" Appendix 4.1. These phases cover the following:

Phase I: Technology reviews that lead to detailed specifications to fill pumpables, weighed/volumetric and placeables.

Phase II: The selected subcontractors will prepare drawings, fabricate and assemble at their site.

PhaseIII: Testing/Modifying and demonstration runs as required.

The chart reflects a time extension that was requested and approved. The extension was needed due to the long approval process for subcontracts. The chart was further modified to track progress of each individual filling system.

3.0 Short term Project Activities

Phase I

3.1 Review Current Technology

A review of existing filling equipment was made. This included a literature search and visits to several vendors to discuss our engineering requirements. Vendors were contacted/visited and brochures and descriptive literature was obtained. (See Appendix 4.2)

3.2 Preliminary Engineering

Filling tests were made at Solbern, Eagle and Ishida with meat and vegetables. Cup dumping tests were performed to evaluate the Solbern transfer cup concept. Working with their engineering department we suggested that their transfer cup be modified to have a movable bottom so that two products can be placed into the cup. This improved accuracy and provided for an easy adjustment to change the cup volume. (See Appendix 4.2)

We held meetings with several other vendors to discuss how their equipment would meet our requirements. As a results of these meetings and tests, specifications and drawings were prepared for all the filling equipment. (See Appendix 4.2)

3.3 Cost Analysis Benefits

A Non-traditional Capital Investment Criteria (NCIC) analysis was conducted on the meat filling system evaluating weigh filling vs volumetric filling with in line checkweigher (See Appendix 4..9). The analysis compared direct capital, labor, material costs and benefits from other factors such as product and equipment flexibility. The NCIC analysis concluded that volumetric filling with in line checkweighing was the preferred solution with a savings of $186,000. This was largely due to the differences in product flexibility and equipment flexibility

between volumetric and weigh filling.

3.4 Design/Development Drawings

A pilot plant concept drawing was made showing the filling equipment in relation to the MRE pouch line and the Tray Pack Line. (See Appendix 4.3 & 4.4)

As part of the Specifications for all the filling equipment, the subcontractor furnished equipment drawings.

<u>Phase II</u> (Liquids, Meat, Vegetables, Placeables)

3.5 Subcontracts/Awards

As a result of pre-bid conferences held the following companies were awarded subcontracts; Oden (liquids), Solbern (meats), FEMC (vegetables) and Adept (placeables). They were evaluated based on the following criteria: delivery, cost, performance, engineering features, service and training.

3.6 Fabrication/Assembly/Monitoring

Purchase orders were issued to Oden, Solbern, FEMC and Adept for filling equipment. Their progress was monitored closely to be sure they were following our specifications and meeting the delivery dates.

In a review meeting with Oden Corp. we suggested that the filler be modified from a 6 head filler to a 3 head/6 nozzle design. This change produced a substantial cost savings while maintaining all performance requirements. The technical advantages include; smaller overall size, less maintenance and ease of operation.

3.7 Testing/Debugging

All the filling machines were given acceptance tests at the vendor's facility. Where possible as much debugging was done in their facility. However, many debugging problems do not occur until the equipment is installed and put into production.

3.8 Install at Site

The vendors installed all of the filling equipment. There were varying degrees of debugging required when the machines were tested in production. The most extensive debugging was done on the FEMC vegetable filler. A rotary funnel assembly was added by FEMC after extensive filling tests in our plant revealed that more time was needed for the product to travel from the hopper to the Solbern cup. The Adept feeding conveyor was also modified to improve the vision capability to sense the ham slices. The wet ham slices were reflecting light back to the camera causing an erroneous image and the robot not picking up ham slices. To solve this the ham slices were back lighted by using a translucent conveyor belt and cutting a hole in the conveyor bed and placing a light under the conveyor thereby creating a shadow of the ham slice. This corrected the problem of ham slices not being picked up by the robot gripper.

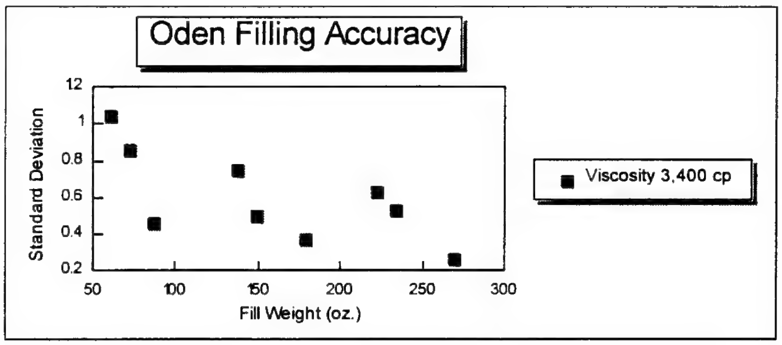
3.9 Plan/Design Tests and Demos.

Design tests and short demonstration runs were made to confirm that the equipment has been completely debugged. The FEMC Filler for vegetables could not be tested in our plant until the Solbern Filler was completely installed.

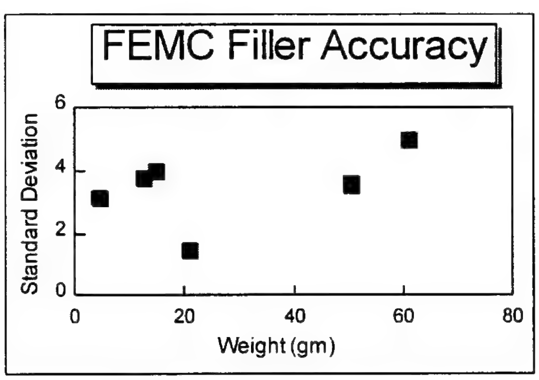
Phase III

3.10 Testing/Modifying Runs

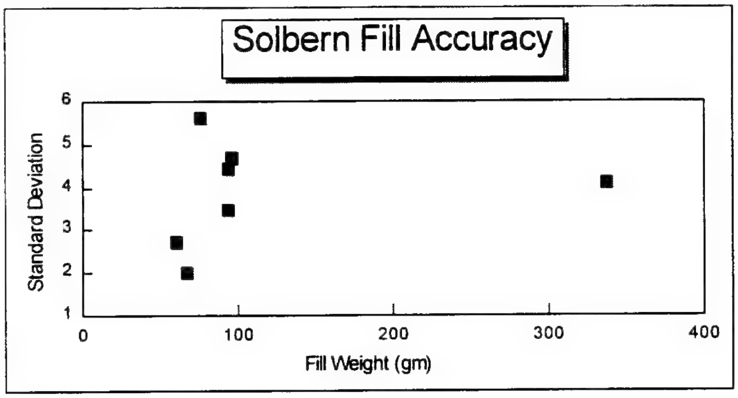
Filling accuracy tests were made on the Oden Liquid Filling Machine (Appendix 4.5.4). The tests were conducted using modified filling nozzles. Filling accuracy was plotted against pump speed, product viscosity and filling cycle time (volumne). All the specifications were met including: filling rate, volume range, accuracy and no liquid dripping between fill cycles..



Filling accuracy tests were made on the FEMC Rotary Volumetric Filler (Appendix 4.6.4). Initial tests were inconclusive due to product bridging in the discharge funnels. To correct this funnels were redesigned for a less steep angle.



Solbern accuracy tests (Appendix 4.7.4) revealed that while the filler was accurate some of the product was sticking to the transfer cups. This was corrected by knurling the bottom movable plate.



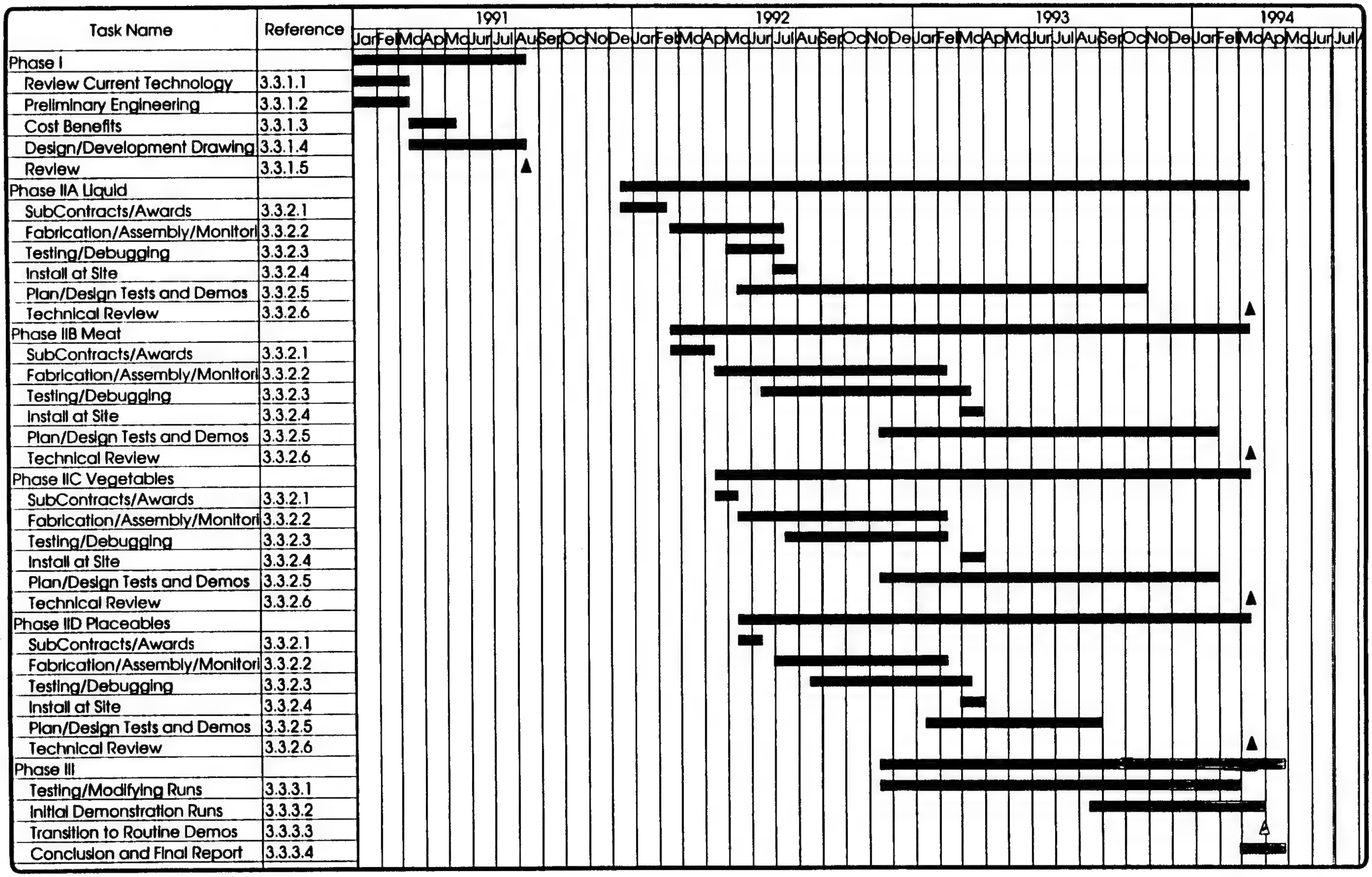
3.11 Initial Demonstration Runs

A robot demonstration was held placing ham slices into the MRE pouch for attendees of the "Conference on Computer Integrated Manufacturing in the Process Industries" (CIMPRO'94) April 26, 1994 (Appendix 4.8.4).

Appendix 4.0

Appendix 4.1
Projected Time & Events and Milestones

Fig 1 - CRAMTD Short Term Project #2
Filling Systems
Projected Time Events and Milestones

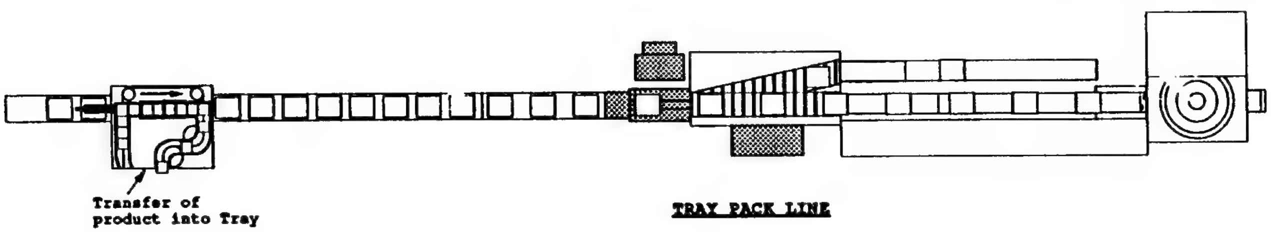


Printed: Oct/10/94

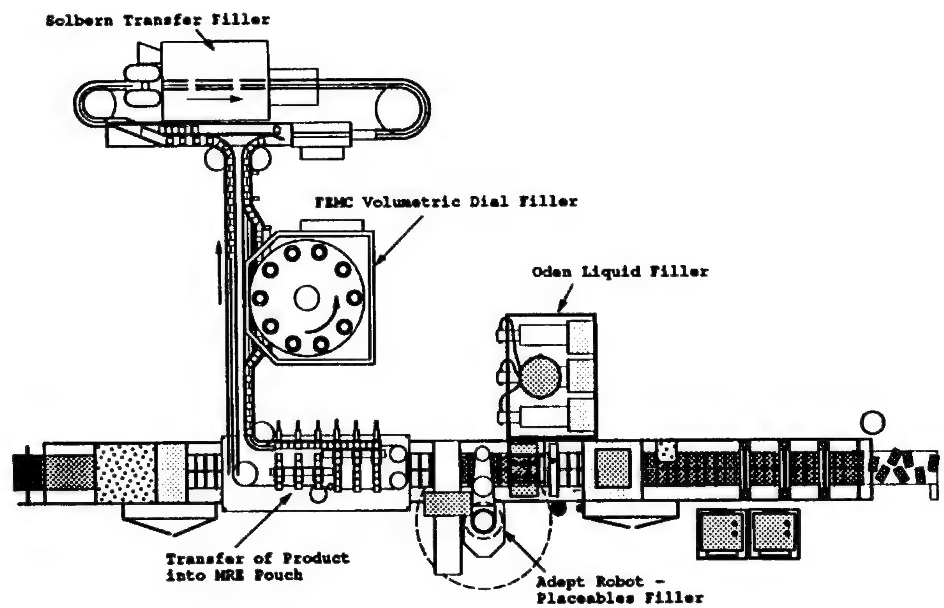
Appendix 4.2
Filling System on MRE Line

FILLING SYSTEM ON MRE LINE

- Indexing line
- Low fill volume
- Multiple fills - 6 per index
- 8 oz. fill in 4 3/4" x 8" pouch

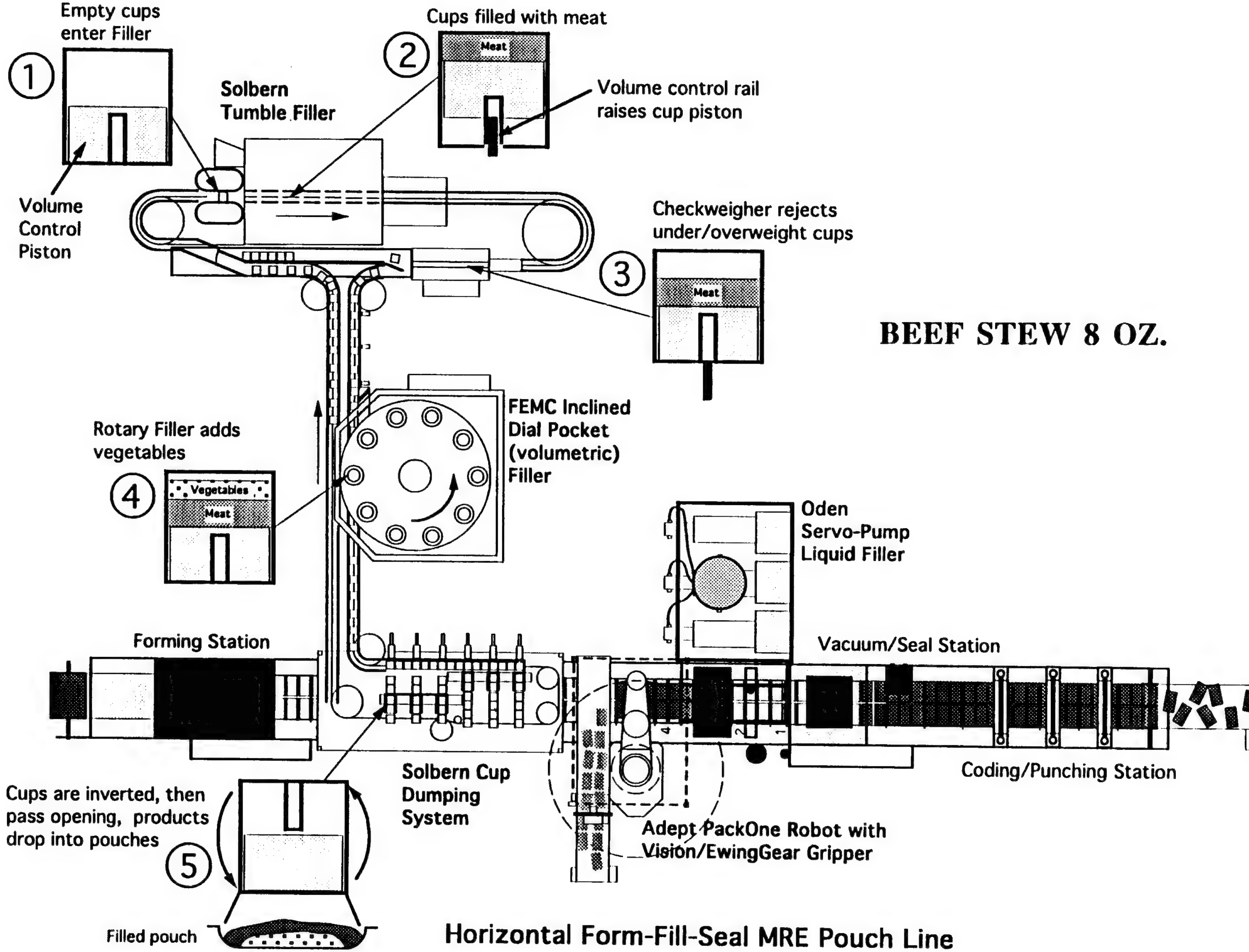


TRAY PACK LINE



MRE POUCH LINE

BEEF STEW 8 OZ.



Horizontal Form-Fill-Seal MRE Pouch Line

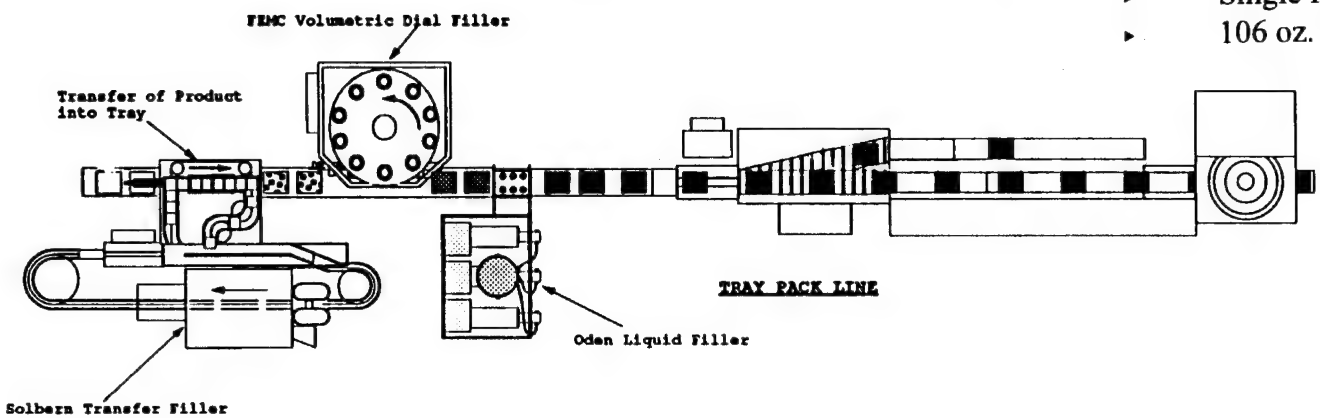
4.2.1

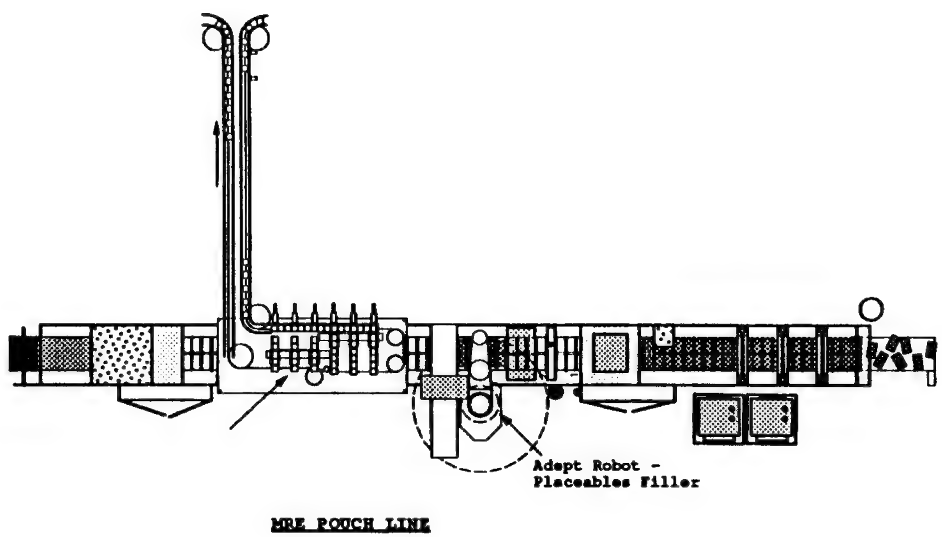
Appendix 4.3

Filling System on Tray Pack Line

FILLING SYSTEM ON TRAY PACK LINE

- Continuous motion line
- High fill volume
- Single fill
- 106 oz. in 10" x 12" tray





Appendix 4.4
Liquid Filling

>DEN

4.4.1

RFP# 1-5-30-2

The State University of New Jersey

RUTGERS

Cook College - Center for Advanced Food Technology

CRAMTD Program

Specifications

for

LIQUID (Gravy/Sauce) FILLING MACHINE

This specification covers the requirements for a liquid filling machine that will be used for the CRAMTD Program under STP #2 - Filling Systems for Combat Rations and Other Food Processes.

The machine will be used for the CRAMTD program demonstration site and for research and development of new packaging methods and materials.

This specification consists of the following sections.

1. Performance Requirements
2. Food Product Information
3. Package Information
4. Design Requirements
5. General
6. Acceptance
7. Shipping and Installation

1.0 Performance Requirements

1.1 Operational Duty. The equipment is to be capable of continuous operation in a typical food production environment. Minimum Operating Efficiency is 95%. This equipment must operate in a typical washdown area and must withstand the use of detergent

cleaning. Cleaning time will be provided daily as required by regulatory agencies (i.e. FDA, USDA) or at least once per day.

1.2 Filling Rate. The equipment shall be capable of at least 20 fill cycles per minute. Each cycle will fill six pouches per index. The fill cycle will be accomplished within 2.0 seconds of the "Start Fill" signal. The proposal should include an option to fill a continuous motion conveyor line at a rate of 30 trays per minute.

1.3 Pouch Filling. The equipment will dispense the food product without causing splash to the pouch seal area and will not drip liquid between fill cycles.

1.4 Food Products. Filling equipment must meet Performance Requirements for food products specified in 3.0 Food Product Information.

1.5 Fill Volume. The equipment will fill from 1 ounces to 8 ounces per pouch. The proposal will include an option to fill from 11 ounces to 110 ounces per tray. The equipment will fill within +/- 1.0% or better of the set volume throughout the entire volume range.

2.0 Food Product Information

2.1 Food product will be sauce.

2.2 Liquid viscosities from 1 cp to 10,000 cp.

2.3 Fill temperatures from 28F to 180F.

2.4 Liquid containing up to 20% particulates of up to 2 mm in diameter.

3.0 Package Information

Pouches as per Drawing A, attached, will be filled simultaneously. Filling equipment should be capable of other pouch arrangements with minimal changes.

4.0 Design Requirements

4.1 Mechanical. Vendor to specify type of filling mechanism (i.e. positive displacement pump servo motor driven, piston pump pneumatic driven, controlled feed tank, etc.) and all necessary equipment. If a traveling head design is proposed, line speed synchronization for the continuous motion conveyor will be provided by a Fenner M-Track controller.

4.2 Pneumatic service up to 100 psi. Vendor to specify pneumatic requirements.

4.3 Electrical. Voltage: 208v or 120v. Vendor to specify power requirements. All wiring, connections, control boxes, enclosures and components shall conform to NEMA 4 standards.

4.4 Controls. The equipment can be operated manually (single fill) or automatically. Automatic operation upon "Start Fill" signal from buyer's PLC. The filling equipment should be capable of returning a signal to the PLC. Equipment should be provided with visual alarm in the event of malfunction. Settings for fill volume and fill duration of fill cycle should be easily adjusted and reproducible.

4.5 Construction. The equipment is to be mounted on castors and provide for easy alignment to the filling station as defined by Drawing A, attached. USDA requirements for food handling equipment apply. Exterior of equipment is to be stainless steel or metal covered with USDA approved white epoxy paint.

4.6 Physical dimensions, including location of utility hook-ups and weight of the equipment are to be provided.

4.7 Cleanability. Vendor will make every effort to facilitate cleaning, both internally and externally, and free from crevices.

4.8 Safety. Vendor will design filling equipment that is safe to operate. Applicable OSHA regulations must be observed.

4.9 Engineering Features. The vendor is encouraged to identify additional features which demonstrate equipment versatility.

5.0 General

5.1 Cost. The proposal is to include total cost be F.O.B. Rutgers University, Food Science Building, Cook College, New Brunswick, NJ. Additional cost of recommended spare parts and accessories not required by this specification should also be quoted but clearly delineated from base bid.

5.2 Delivery Schedule. The vendor will specify engineering design, fabrication, testing and delivery schedule.

5.3 Service. The vendor will provide service as needed to fulfill requirements of the warranty and these specifications.

5.4 Drawings, Photos. A layout drawing of this machine shall be provided in both plan and elevation views with the proposal. Photos shall be provided as needed.

5.5 Award. The criteria for selecting a proposal will be based on the evaluation of the CRAMTD staff:

Delivery
Performance
Engineering Features
Cost
Service
Training

5.6 Exceptions. The vendor is to clearly identify any exceptions taken from these specifications.

5.7 Warranty. The vendor warranties the equipment performance specified herein for one year from the date of acceptance.

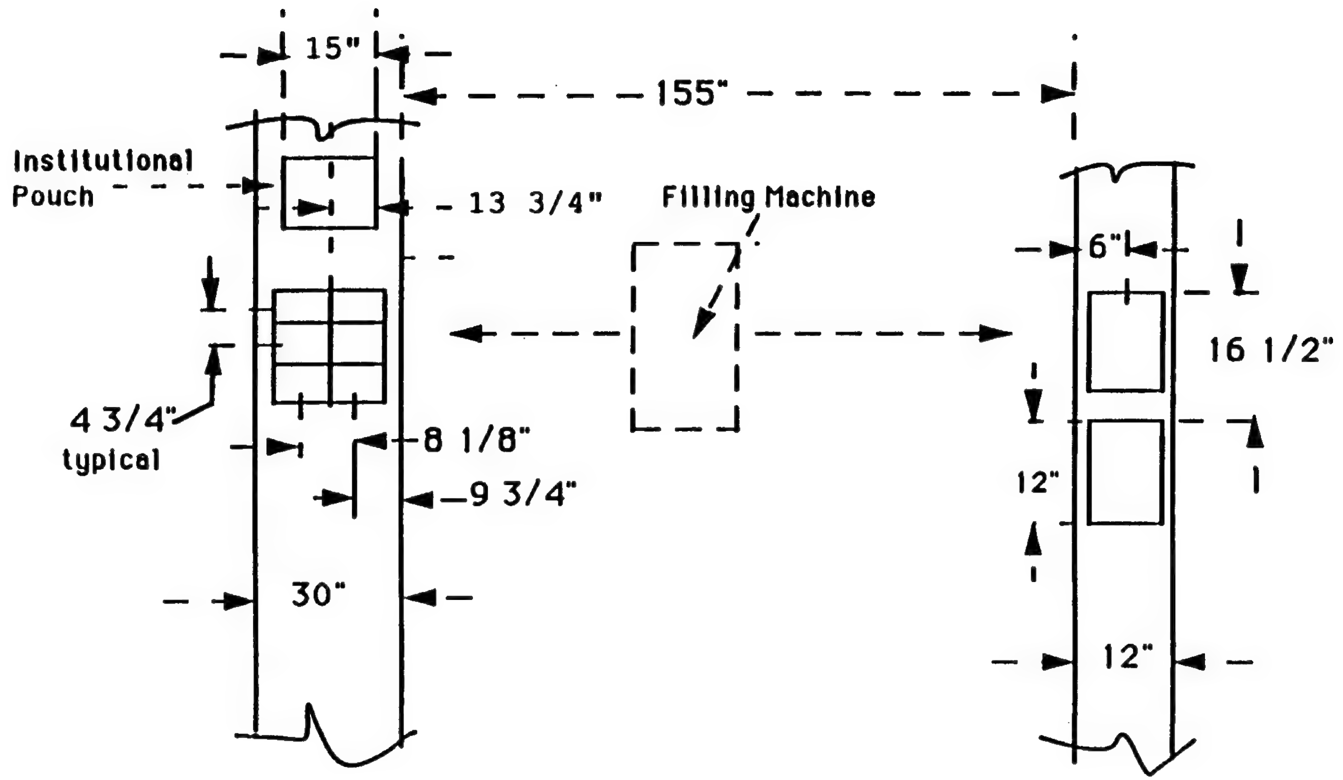
6.0 Acceptance

Acceptance Test. The equipment will be subject to an Acceptance Test to determine whether performance requirements have been met. The equipment will fill pouches for one hour at 17 cycles per minute. The equipment will fill trays on the continuous motion line for one hour at 20 trays per minute. Random samples will be taken and measured for accuracy of fill volume.

7.0 Shipping and Installation

7.1 The equipment will be shipped F.O.B., Rutgers University, Food Science Building, CAFT, Cook College, New Brunswick, NJ 08903.

7.2 The vendor will assemble equipment in full working order and provide training to Rutgers personnel in the operation and maintenance of the equipment.



HORIZONTAL FORM/FILL/SEAL MACHINE
INDEXING

Interior dimension of each pouch= 6 1/2"x3 1/8x7/8"
" " of institutional pouch= 12"x15"x2"
Height from floor = 36 1/2"

TRAY PACK LINE
CONTINUOUS MOTION

Interior dimension of tray=12"x10"x2"
Height of tray top from floor=48 1/2"

Ceiling height = 9'-0"

DRAWING "A"

Vendors for STP# 1 - Liquid Filling Filling Equipment

Oden Corporation
255 Great Arrow Avenue
Buffalo, NY 14207
Attn: Joel Slazyk
716 874-3000

HIBAR Systems Limited
4718 Oakwood Lane
Nazareth, PA 18064
Attn: Joe Baldanza
215 837-9001

Modular Packaging Systems, Inc.
45 Route 46
P.O. Box 724
Pine Brook, NJ 07058
Attn: Michael McNeila
201 882-0633

Hinds-Bock Corporation
14690 N.E. 95th Street
Redmond, WA 98052
Attn: Lance Aasness
206 885-1183
cc: Quantum Precision Packaging
    215 674-0443

Food Equipment Manufacturing Corporation FEMC
16900 Rockside Road
Maple Heights, OH 44137
216 663-1208

Raque Food Systems, Inc.
P.O. Box 99416
11002 Decimal Drive
Louisville, KY 40299
Attn: Jack Hayden
502 267-9641

Autoprod Inc.
5355 115th Avenue North
Clearwater, FL 34620
Attn: Paul DeSocio
813 572-7753

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

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(908)932-3000 • FAX (908)932-4712

June 13, 1991

The following has been sent to Oden Corp.; Hinds-Bock Corp.; Food Equipment Mfgr. Corp.; Modular Packaging Systems Inc.; Raque Food Systems and Auto Prod. Inc.

RE: ADDENDUM #1 TO RFP #1-5-30-2 LIQUID (GRAVY/SAUCE) FILLING MACHINE

The information contained herein revises, supplements and/or supercedes the specific parts of the documents referred to as request for proposal number 1-5-30-2. Except as herein modified, all other provisions for the proposal request shall remain in full force as originally set forth.

Gentlemen:

1. Paragraph 1.1, "detergent cleaning" will be with non-caustic detergent, bleach and high pressure water.

2. Paragraph 1.2, the proposal should also include as an option to fill an Institutional sized pouch, 12" x 15" x 2", with the same fill volumes as required for the tray. The Institutional pouch will be filled within 2.0 seconds at a rate of 20 pouches per minute (indexing motion).

3. Paragraph 1.4 has a typographical error and should read: "...2.0 Food Product Information."

4. Paragraph 4.1, a servo motor to control fill volume and speed is preferred but not required. The filling machine should have the ability to use any combination of one to six nozzles.

5. Add new paragraph: 4.10 Feed Hopper. Filling equipment is to include a feed hopper of 30 to 50 gallon capacity. The hopper will have a removable cover. The hopper may be top fed or bottom fed and provided with a 1.5 inch Cherry Burrell pipe connector. If bottom fed, a shut off valve is required. The hopper will have level sensing and provide a contact to operate a feed pump to maintain proper level. Hopper agitation should be included as an option.

6. Paragraph 4.4, the visual alarm should only be activated by a level condition in the hopper.

7. Paragraph 4.4, the filling machine will include a sensor to detect trays. The sensor may be mounted on the conveyor.

8. Paragraph 4.5, the exterior of the equipment may also be made of anodized or coated aluminum.

9. Paragraph 7.2, the vendor will assemble and install the equipment at Rutgers.

10. Drawing "A" should include a Ceiling Height of 9 feet.

11. All options shall be priced individually and included on a separate sheet within your proposal.

12. All Addendums must be acknowledged by <u>signing</u> Page 2, Section 8 of the official bid document. Failure to do so will result in the disqualification of your proposal.

Sincerely,

Michael H Dunn

Michael H. Dunn
Senior Buyer

MD/kdl

c: T. Descovich - CAFT/CRAMTD
N. Litman - CAFT/CRAMTD
G. Thorn

COPY

THIS IS NOT AN ORDER

PISCATAWAY, NJ 08855-6999

R.F.Q.P ~~1-5-30-2~~

1. RETURN SIGNED QUOTATION IN A SEALED ENVELOPE. SHOW RFQ # ON OUTSIDE OF ENVELOPE.
2. IN EVENT OF THIS BID BEING ACCEPTED, A PURCHASE ORDER WILL BE SENT.
3. SEE REVERSE SIDE FOR TERMS & CONDITIONS.
4. ANY EXPENSE INCURRED BY THE BIDDER IN CONNECTION WIT THIS QUOTATION IS THE SOLE RESPONSIBILITY OF THE
5. IF QUOTE IS NOT F.O.B. DESTINATION, YOU MUST SHOW OF FREIGHT AS A SEPARATE ITEM.

ATTN: JOEL SLAZYK
ODEN CORPORATION
225 GREAT ARROW AVE.
BUFFALO, NY 14207

4.4.2

DATE	THIS BID WILL BE OPENED:		BY
5/30/91	SEALED PROPOSAL DUE JUNE 27, 1991	TIME: 2 PM	GEORGE THORN, DIRECTOR OF PURCHASES

PLEASE QUOTE THE FOLLOWING F.O.B. DESTINATION

RUTGERS-THE STATE UNIVERSITY OF N.J., requests proposals for the design, manufacturer & installation of a liquid filling machine in accordance with the attached specifications and following notes:

NOTES:

A. MANDATORY PRE-BID CONFERENCE/SITE INSPECTION
IT IS MANDATORY THAT ALL PROSPECTIVE VENDORS ATTEND THIS PRE-BID CONFERENCE IN ORDER TO CLARIFY ANY SPECIFICATIONS/DETAILS AND ACQUAINT THEMSELVES WITH THE PROPOSAL TO BE SUBMITTED. EACH VENDOR MUST SIGN THE REGISTER TO VERIFY HIS/HER ATTENDANCE. FAILURE O ATTEND THIS PREBID CONFERENCE WILL RESULT IN DISQUALIFICATION OF YOUR PROPOSAL.

The Pre-Bid Conference will be held:

DATE: JUNE 12, 1991
TIME: 1:30 PM
LOCATION: Rutgers University Food Science Building, CAFT, corner of College Farm & Dudle Roads, Conference Room #120A, New Brunswick, NJ 08903

B. Technical questions pertaining to specifications are directed to Mr. Theordore Descov h at 908-932-8307. Questions pertaining to proposal procedures are directed to Mr. Michae Dunn at 908-932-5070.

C. The following areas must be addressed in detail with each proposal and will be considered in the evaluation: Delivery, performance, engineering features, cost service and training.

D. Prices are to be F.O.B. Rutgers University Food Science Building, CAFT, Cook College, ew Brunswick, NJ. freight included.

PLEASE INDICATE COST OF PROPOSAL AS FOLLOWS:

LUMP SUM $ 122,635.00

This represents base price. Please see Quotation No. 11107 Section G "Price" for options.

Delivery & Installation 100-120 Days ARO

All prices are subject to 10% educational discount.

1. Please note additional Terms & Conditions on reverse side of this sheet.
2. It is the bidders responsibility to see that their proposal arrives at the University Procurement & Contracting Office before the proposal opening date and time.
3. Proposals delivered in person or by express service should be to our actual location. This location is:
RUTGERS -THE STATE UNIVERSITY of New Jersey
University Procurement & Contracting
Administrative Services Annex Building/Room 101,
Davidson Road/Busch Campus
PO Box 6999
Piscataway, NJ 08855-6999

REFER ALL QUESTIONS REGARDING THIS REQUEST TO:	NOTE: SHOW ALL TAXES AS SEPARATE ITEM	GRAND TOTAL →
MICHAEL DUNN/M/932-5070		

THIS SPACE TO BE FILLED IN BY BIDDER

SHIPMENT CAN BE MADE IN 100-120 DAYS FROM RECEIPT OF ORDER	"We quote you as above subject to the Terms and Conditions on the reverse.
F.O.B. Rutgers University (Per Specifications)	SIGNATURE: Michael W Chiddle 716-874-3000 PHONE NUMBER
TERMS: 1/3 At Time Of Order · 1/3 Prior To Shipment, 1/3 30 days After Startup.	PRINT NAME AND TITLE Michael W. Liddle Vice President

5-002 Rev 5

THIS IS NOT AN ORDER

PISCATAWAY, NJ 08855-6999

R.F.Q. P ~~1-5-30-2~~

1. RETURN SIGNED QUOTATION IN A SEALED ENVELOPE. SHOW RFQ # ON OUTSIDE OF ENVELOPE.
2. IN EVENT OF THIS BID BEING ACCEPTED, A PURCHASE ORDER WILL BE SENT.
3. SEE REVERSE SIDE FOR TERMS & CONDITIONS.
4. ANY EXPENSE INCURRED BY THE BIDDER IN CONNECTION W THIS QUOTATION IS THE SOLE RESPONSIBILITY OF THE BID
5. IF QUOTE IS NOT F.O.B. DESTINATION, YOU MUST SHOW C OF FREIGHT AS A SEPARATE ITEM.

ATTN: JOEL SLAZYK
ODEN CORPORATION
225 GREAT ARROW AVE.
BUFFALO, NY 14207

DATE	THIS BID WILL BE OPENED:		BY	
5/30/91	SEALED PROPOSAL DUE JUNE 27, 1991	TIME: 2 PM		GEORGE THOR
	PLEASE QUOTE THE FOLLOWING F.O.B. DESTINATION		DIRECTOR OF PURCHASES	

4. All cash discount terms will be acceptable, however, terms less than 3%-30 days will no be considered in the proposal award.

5. Proposals should be returned in the enclosed Yellow Envelope or attach the Yellow envelope to the outside of a large envelope, if necessary. Telegraphic and facsimile proposals are not acceptable. Bidders must submit sealed proposals only. Any communication such as (facsimile transmittal) which reveals the contents of a sealed proposal will result in disqualification of entire proposal.

6. Proposal documents submitted with price alterations ie. whiteouts, crossouts, erasures etc. must be initialed otherwise proposal will be rejected. (See number 17, terms & conditions)

7. ATTENTION BIDDERS

THIS ORIGINAL (LEGAL SIZE SHEET) REQUEST FOR PROPOSAL FORM "MUST" BE SIGNED AT THE BOTT AND RETURNED WITH PROPOSAL SHEET(S). YOUR ENTIRE PROPOSAL SUBMITTAL WILL BE REJECTED A DISQUALIFIED IF THIS FORM IS "NOT" SIGNED AND RETURNED ON OR BEFORE THE PROPOSAL DUE DA AND TIME.
FURTHERMORE BIDDERS WHO WISH TO REMAIN ON OUR "QUALIFIED" BIDDERS LIST SHOULD ALSO SIGN AND RETURN THIS PROPOSAL FORM INDICATING A REASON FOR NOT SUBMITTING A PROPOSAL.

8. Any addendums to this Request For Proposal must be acknowledged by signature below. Failure to comply will result in rejection of proposal.

You must sign below for each addendum received.

ADDENDUM: #1 Michael W. Oden (Signature)
#2 ________________ (Signature)
#3 ________________ (Signature)

9. Bidders must comply with all proposal enclosures and must return certain enclosures wit proposal form. Photocopies of any required enclosures are not valid. Those indicated must have original signatures and notary seal. Failure to comply will result in rejection of proposal.
They are:
(1) Affidavit (must be notarized)
(2) Non-Collusion Statement NCS-1 (must be notarized)
(3) PL 1977 C.33 (must be signed)

10. A. Requirement to be provided by successful bidder after proposal award is made.
(1) Insurance, after award and prior to start of work
(2) PL 1975 C.127 within seven (7) days after receipt of purchase order
Note: Bidders are required to comply with the requirements of NJSA 10-31 et. seq. PL 1975, C.127.

B. Supplemental Terms & Conditions, form STC-1 is a notice of requirement for compliance by bidder to whom an award is made and is to be retained by bidder.
Additional enclosures are: Did You Sheet/Specifications/Map

REFER ALL QUESTIONS REGARDING THIS REQUEST TO:	NOTE: SHOW ALL TAXES AS SEPARATE ITEM	GRAND TOTAL →	N/A
MICHAEL DUNN/M/932-5070			

THIS SPACE TO BE FILLED IN BY BIDDER

SHIPMENT CAN BE MADE IN 100-120 DAYS FROM RECEIPT OF ORDER	We quote you as above subject to the Terms and Conditions on the reverse.
F.O.B. Rutgers University (Per Specifications)	SIGNATURE: Michael W. Oden 716-874-3[illegible]
TERMS: 1/3 at Time of Order, 1/3 Prior To Shipment, 1/3 30 days after Start-up	PRINT NAME AND TITLE: Michael W. Laddle Vice President PHONE NUM

5-002 Rev 5

ODEN CORPORATION • 255 Great Arrow Avenue • Buffalo, NY 14207 • Telephone (716) 874-3000 • FAX (716) 874-1589

ODEN CORPORATION

Items Included in Bid Proposal for
Rutgers University
RFP 1-5-30-2
Liquid (Gravy/Sauce) Filling Machine

1 Cover Sheet

2. New Jersey Public Law 1977 C.33

3. Non-Collusion Statement

4. Affidavit

5. Oden Quotation No 11107 - Base System Plus Options

6. Oden Quotation No. P-1264 - Spare Parts

7. Exceptions to Specifications

8. Delivery Schedule

9. Engineering Features

10. Outline Drawing. Includes information as to weight, dimensions and utility inputs.

11 Data Sheet - How Oden Fillers Work

ODEN CORPORATION • 255 Great Arrow Avenue • Buffalo, NY 14207 • Telephone (716) 874-3000 • FAX (716) 874-1589

QUOTATION NO. 11107

TO Rutgers - The State University of New Jersey
University Procurement and Contracting
Administrative Services Annex Building/Room 101
Davidson Road/Busch Campus
P. O. Box 6999
Piscataway, NJ 08855-6999

DATE: June 19, 1991

Attention: Mr. Michael Dunn

We propose to furnish you with the following equipment, subject to the terms and conditions contained herein which are a part of this quotation:

A. MACHINE MODEL

Six (6) Head PRO/FILL 3000 Liquid Filling System, configured with features as follows:

Fillers - Six (6) PRO/FILL 3000 Liquid Fillers, each configured with features as follows:

Pump

1. Waukesha Size 18 Universal Series, 3A sanitary lobe type pump, equipped with Waukesha 88 non-galling stainless steel alloy double blade-double rotors. Pump body is constructed of 316 stainless steel. Shaft seal is single O-ring type. Product feed ports are 1.5" sanitary. The pump will deliver 14 GPM (water curve) at 0 PSI discharge pressure when driven at 500 RPM.

For further information regarding material compatibilities, etc., contact:

Waukesha Pumps
1300 Lincoln Avenue
Waukesha, WI 53186

Pump Drive

2. Heavy duty pump drive consisting of 2500 RPM 1 HP 90 VDC armature P.M. servo motor and in-line 56C face 5:1 gear reducer. Drive train delivers 500 RPM maximum at the shaft. This is a direct drive train and contains no clutches or clutch brakes. One discrete drive assembly per pump head.

Nozzles and Fluid Floor Pathways

3. 12 air operated, electronically controlled inward opening Positive Shut-off Nozzles, each with features as follows:

a. Isolated air cylinder operator.
b. Mechanical stroke adjustment.
c. Nozzle open pump interlock. This prevents the filler from operating should the nozzle fail to open.
d. Electronic control of nozzle closure timing relative to the end of fill.
e. Adjustable nozzle closing pressure.

f. Constructed of 316 stainless steel, Teflon, UHMW with either BUNA-N or Viton O-ring seals.
g. Usable nozzle length approximately 10".
h. Size: 6 with 1" O.D., 6 with 2" O.D. Size may be altered based upon testing.

4 1.5" flexible PVC infeed tubing and 1.0" flexible PVC outfeed tubing.

Electronics

5 Electronic filler controls providing the following functions:

a. Two (2) digit pump speed counter for product flow rate control over 100:1 set point range.
b. Volume control on a five (5) decade digital basis.
c. Two (2) digit "cut-off adjustment" (COA) for electronic adjustment of fill cut-off for no-drip performance.
d. Single fill switch for test, calibration and fill functions.
e. Continuous flow switch for prime and purge functions.
f. Filler stop and start switch.
g. Power on/off switch.

6 Encoder based volume control electronics consisting of a 96 pulse per revolution digital pick-up and counter system. This electronic system provides high resolution, high stability volume control without set point drift. Because absolute rotation is measured, fluctuations in pump speed, temperature and product viscosity are accommodated over a very broad dynamic range without significant change in set point volume. A level controlled product feed reservoir may be required and is recommended to maximize filling accuracy.

7 System to be provided with a no-container-no-fill feature for use when filling trays.

8. System to be capable of accepting a fill signal from existing customer equipment or using a photo eye to trigger fill.

9 Automation Interface Loop (AIL) electronics providing electronically adjustable (0 to 3 second) trigger delay function and adjustable (0 to 3 second) output signal at end-of-fill (EOF). Output signal is implemented through solid state relay at 115 vac 3 amps. Other logic and signal formats are available as required.

Enclosures

10. 304 stainless steel NEMA 4/12 electronics cabinet measuring approximately 16" wide, 20" high, and 13" deep. Cabinet to have sealed Lexan swing door. Electronics module connected to pump module with quick disconnect umbilical in standard lengths of 2 ft., 6 ft. or 10 ft.

11. 304 stainless steel pump module, measuring approximately 10" wide, 15" high, and 37" deep.

Nozzle Supports

12. Nozzle supports for both pouch and tray filling are to be provided.

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Reservoir

13. Free standing product reservoir consisting of a 304 stainless steel cylindrical tank type reservoir with a capacity of approximately 40 gallons. Hopper cover to be loose fitting and constructed of 304 stainless steel. Reservoir to have six (6) 1.5" tri-clamp product feed ports, one 1.5" tri-clamp product supply port and one (1) 1.5" tri-clamp overflow port. Reservoir dimensions are 30" high and 20" in diameter. Empty weight is approximately 55 pounds.

    Reservoir to include Oden electronic level control system. This system utilizes an ultrasonic sensor to monitor product level and close a switch which automatically actuates your feed pump or other feed device such as a solenoid valve.

    Reservoir inlet to be supplied with a ball valve type shut-off device. In addition, the level control will trigger a visual alarm when a low-low level is reached.

Other

14. Entire system to be mounted on a 304 stainless steel stand constructed of 2" x 2" stainless steel tubing. The stand is to be mounted on locking casters for ease of movement.

15. Installation and training assistance. This is estimated to take four (4) days but will be extended if necessary. Because system is shipped intact installation is minimized. All expenses of travel, lodging, etc. are to be responsibility of Oden Corporation.

B. OPTIONAL FEATURES AND SPECIFICATIONS

Servo Motor Drives

1. The use of servo motors to drive Waukesha pumps is the standard design of Oden fillers. Thus an extremely versatile range of filling (1/2 oz. - 1 gallon, or more) is inherent to Oden liquid fillers. In addition, the use of servo controls allows for repeatable digital settings of filler pump speed and volume.

Option to Fill Trays at Rate of 30 Trays Per Minute

2. This option requires the use of nozzle change parts to increase the diameter and a nozzle positioning system to allow for the use of either multiple nozzles per tray or the ability to step fill trays. The technique to be used is subject to testing.

Option to Fill Institutional Pounch at Rate of 20 Pouches Per Minute

3. This option requires the use of nozzle change parts to increase the diameter and a nozzle positioning system to allow for the use of either multiple nozzles per position or the ability to step fill trays. The technique to be used is subject to testing.

Hopper Agitation

4. Hopper agitation system to consist of a Lightnin variable speed mixer with reservoir mounting hardware.

C. CUSTOMER RESPONSIBILITIES

Customer is responsible for providing the following:

1. Air: 80 PSI @ 6 - 8 SCFM. Filtered dry, non-lubricated air preferred.

2. Electricity: 115 VAC 50/60 Hz 18 AMP Single Phase. One line cord per filler.

3. Product Feed System: Level control of product supply is recommended to attain best fill accuracy possible. Level control is provided with the system.

D. PRODUCTS TO BE FILLED

Various food sauces with particulates up to 2 mm in diameter.

No performance specifications or guarantees shall apply to any products not herein specifically listed.

SPECIAL NOTE: THIS MACHINE AS QUOTED IS NOT DESIGNED FOR USE WITH FLAMMABLE LIQUIDS OR IN EXPLOSIVE ENVIRONMENTS.

E. DELIVERY

Machine shipment will be made or acceptance runs scheduled for 14 to 16 weeks after order acceptance as defined by the Terms stated below. *

The above delivery reflects our current production schedule. Quoted delivery represents our best estimate and is non-binding and subject to change.

F. TERMS

1/3 Deposit with order, 1/3 prior to shipment, Balance Net 30. Any amounts not paid when due shall bear interest at 1-1/2% per month or the highest rate allowed by law, whichever is less.

Any credit terms extended by Oden are subject to evidence of satisfactory credit rating and may be altered or withdrawn based upon credit investigation.

Purchaser hereby grants to Oden a security interest in any and all equipment sold to Purchaser, which security interest shall continue until all charges for the equipment are paid in full by Purchaser to Oden. Purchaser hereby agrees that Oden may execute and file UCC-1's with or without the Purchaser's signature in order to perfect said security interest.

* NO ORDER WILL BE ENTERED INTO OUR PRODUCTION SCHEDULE WITHOUT YOUR AUTHORIZING PURCHASE ORDER, CORRESPONDING DEPOSIT MONEY, AND A SIGNED COPY OF THIS QUOTATION.

All prices are F.O.B. Rutgers University, Food Science Building, CAFT Cook College, New Brunswick, NJ 08903.

G PRICE

		Total
Six (6) Head PRO/FILL 3000 Liquid Filler		$122,635.00
Optional Features:	B-1 Servo Motor Drives	N/C
	B-2 Trays at 30 CPM	7,225.00
	B-3 Pouches at 20 CPM	7,225.00 *
	B-4 Reservior Agitation	5,700.00

* $3,000.00 if Option B-2 is purchased.

NOTE: All prices subject to 10% educational discount.

WE ACCEPT THIS QUOTATION AND ACKNOWLEDGE ODEN'S LIMITED WARRANTY AS ATTACHED TO THIS QUOTATION.

ODEN CORPORATION

BY: Michael W. Lake V.P.

FOR THE CORPORATION

Authorized Signature

Date

Please sign and return a copy of this Quotation to Oden Corporation.

ODEN CORPORATION • 255 Great Arrow Avenue • Buffalo, NY 14207 • Telephone (716) 874-3000 • FAX (716) 874-1589

CONDITIONS OF SALE

PRICES

Prices quoted are those currently in effect.

TERMS

As stated within this quotation

DELIVERY

Delivery dates quoted are based on the best information now available. We cannot guarantee delivery on the specified date since we have no control over matters such as deliveries from our suppliers, labor difficulties, governmental regulations, accidents, etc.

WARRANTY TO THE ORIGINAL PURCHASER:

We warrant for a period of 12 months from date of shipment from our factory all electronic components of our manufacture or assembly, to be free from defects in material and workmanship. We assume no responsibility for said equipment or its operation other than to replace, without charge, such parts as determined to be defective.

Seller's liability under this agreement shall be limited to the purchase price of the machine(s) and shall in no event include Purchaser's manufacturing costs, loss of profits, products, material or good will, or any other special or consequential damages.

LIMITED WARRANTY

A. WARRANTY:

Oden warrants that at the time of shipment, the products manufactured by Oden, and sold hereunder shall be in conformity with applicable written specifications and descriptions referred to or set forth herein, free from material defects in materials and workmanship. Except for the express warranties, stated herein, Oden disclaims all warranties on products furnished hereunder, including without limitation all implied warranties of merchant ability and fitness. The stated express warranties are in lieu of all obligations or liabilities on the part of Oden arising out of or in connection with the performance of the products.

B. WARRANTY ADJUSTMENT:

1. Oden agrees to repair or furnish a replacement for, but not remove or install, any product or component thereof which, within twelve (12) months from the date of shipment by Oden shall, upon test and examination by Oden, prove defective within the above warranty.

2. Buyer shall notify Oden of any defect within this warranty no later than thirty (30) days after a defect is discovered.

3. No product shall be accepted for return or replacement without the written authorization of Oden. Upon such authorization, and in accordance with instructions from Oden, the product will be returned to Oden addressed as follows:

ODEN CORPORATION
255 Great Arrow Avenue
Buffalo, New York 14207

or to such alternate locations as may be designated on the product or its container. Oden Corporation will absorb shipping charges up to a maximum of the United Parcel Service "Blue Label" rate. Any additional charges shall be the responsibility of the customer. All shipping charges for shipments to or originating from points outside continental United States and Canada shall be the responsibility of the customer.

C. EXCLUSIONS FROM WARRANTY:

1. This warranty is limited solely to the above and applies only for the period set forth.

2. Oden will not be liable for any loss, damage, incidental or consequential damages of any kind, whether based upon warranty, contract, or negligence, and arising in connection with the sale, use or repair of the products.

3. Oden's maximum liability shall not, in any case, exceed the contract price for the products claimed to be defective or unsuitable.

4. This warranty does not extend to any product manufactured by Oden which has been subjected to misuse, neglect, accident, improper installation, or use in violation of instructions furnished by Oden.

5. This warranty does not extend to or apply to any unit which has been repaired or altered at any place other than at Oden's factory or by persons not expressly approved by Oden, nor to any unit the serial number, model number or any identification of which has been removed, defaced, or changed.

6. Components manufactured by any supplier other than Oden shall bear only that warranty made by the manufacturer of that product.

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QUOTATION NO. P-1264

TO: Rutgers - The State University of New Jersey
University Procurement and Contracting
Administrative Services Annex Building/Room 101
Davidson Road/Busch Campus
P. O. Box 6999
Piscataway, NJ 08855-6999

DATE: June 19, 1991

Attention: Mr. Michael Dunn

We propose to furnish you with the following equipment, subject to the terms and conditions contained herein which are a part of this quotation:

A. DESCRIPTION

		Price	Suggested On Hand Quantity
Electronics			
1.	Complete Electronic Pump Controller (usable in any system position)	$4,970.00 ea.	1
2.	12 Volt Encoder Pick Up Sensor	$102.00 ea.	1
3.	5 Decade Volume Deck	$105.00 ea.	1
4.	2 Decade Pump Speed Deck	$35.00 ea.	1
5.	Complete Filler Control Panel	$560.00	1
Positive Shut-Off Nozzle			
1.	3-Way Valve for Positive Shut-Off Nozzle	$61.00 ea.	2
2.	Reed Switch Interlock for Positive Shut-Off Nozzle	$78.00 ea.	2
3.	Positive Shut-Off Nozzle Shaft Seal	$19.00 ea.	6
4.	Air Cylinder for Standard Positive Shut-Off Nozzle	$102.00 ea.	1
Pump - Waukesha Size 18			
1.	O-Ring Rebuild Kit - Viton	$62.50/set	6

B. DELIVERY

Delivery will be made as soon as possible after receipt of order.

Items requiring custom fabrication or which may currently be out of stock will be shipped as soon as practical after receipt of order.

C TERMS

Net 30

NOTE: MINIMUM ORDER $25.00.

NO ORDER WILL BE ENTERED INTO OUR PRODUCTION SCHEDULE WITHOUT YOUR AUTHORIZING PURCHASE ORDER.

All prices are F.O.B. Buffalo, NY.

Any on-site engineering and/or installation assistance by Oden Corporation shall be billed out at the current hourly rate of $51.00, plus expenses incurred.

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Rutgers University

RFP 1-5-30-2

Liquid (Gravy/Sauce) Filling Machine

Exceptions to Specifications

Specification Reference	Exception
1.5 - Fill Volume	We anticipate the equipment can fill all required volumes at ± 1%. However, we feel testing is necessary to guarantee accuracy at fill volumes of 3 oz. and less. At greater than 3 oz., with the types of products specified, the equipment will dispense at ± 1% or better.
1.2 - Filling Rate	Filling rate is dependent upon both the product characteristics and the containers' ability to accept a flow rate high enough to achieve desired speeds. We anticipate the quoted system can operate at desired speeds but final speeds are dependent upon product and containers used.

NOTE: All other stated specifications to be complied with.

Rutgers University

RFP 1-5-30-2

Liquid (Gravy/Sauce) Filling Machine

5.2 Delivery Schedule

Event	Days After Order
Engineering Design	30-60
Component Acquisition and System Fabrication	40-100
Testing	90-110
Delivery	100-120

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Rutgers University

RFP 1-5-30-2

Liquid (Gravy/Sauce) Filling Machine

Engineering Features

A. Construction Features

1. Single Assembly

One complete stainless steel stand mounted assembly. This unit can simply be rolled and locked into place for quick set up.

2. Stainless Steel Contruction

Total stainless steel construction for durability in a demanding food filling environment.

3. NEMA 4

NEMA 4 enclosures to withstand the food filling environment.

B System Design and Control Features

1 Servo Motor Based Drives

Please refer to the enclosed data sheet "How Oden Fillers Work" for a detailed explanation of our servo motor based fillers.

2 Digital Controls

Digital control over all filling parameters (pump speed, volume and cut-off adjustment) makes set up extremely easy and repeatable.

3. Pumps

Oden Liquid Fillers designed for use in a food environment use Waukesha Universal Series Lobe pumps. These pumps are a standard in a food plant due to their durability, ease of use and sanitary features. In addition, they can be thermal cycled up to 200ºF (or even higher if necessary) for a hot water flush.

C. Versatility Features

1. Fill Size

Because we design fillers around the use of servo motors and rotary motion pumps we can dispense products in volumes ranging from one ounce to one gallon (or more) without the need for change parts

2. Viscosity

   Products with viscosities ranging from water-like through paste-like can be dispensed by our system. Our use of 1 HP servo motors and inline helical gear reducers provide significant torque at the pump to pump very viscous products.

3. Operator Convenience

   Digital set up of pump speed and volume makes our fillers very convenient for operators. Once settings are determined for a particular product and fill size, the settings can be re-entered for subsequent runs.

D. Possibilities

1. Use a Varying Number of Fillers

   Because of the modular construction methodology utilized by Oden and the fact each pump has its own drive, it is extremely easy to use any number of fillers up to the number provided. Each filler has its own "lock out" switch which makes disabling any head as easy as flipping a switch.

2. Nozzle Arrangement

   Nozzles can be arranged in virtually any combination. An application may require more than one nozzle per container and with Oden fillers, this is easily accomplished.

3. In Line Mixing

   Because independent control is maintained over each fill head, it is possible to dispense different ingredients into a container in varying amounts. A step filling technique with Oden fillers makes this possible. Simply supply pumps with the desired products, calibrate and step containers under each nozzle.

4. Benchtop Filling

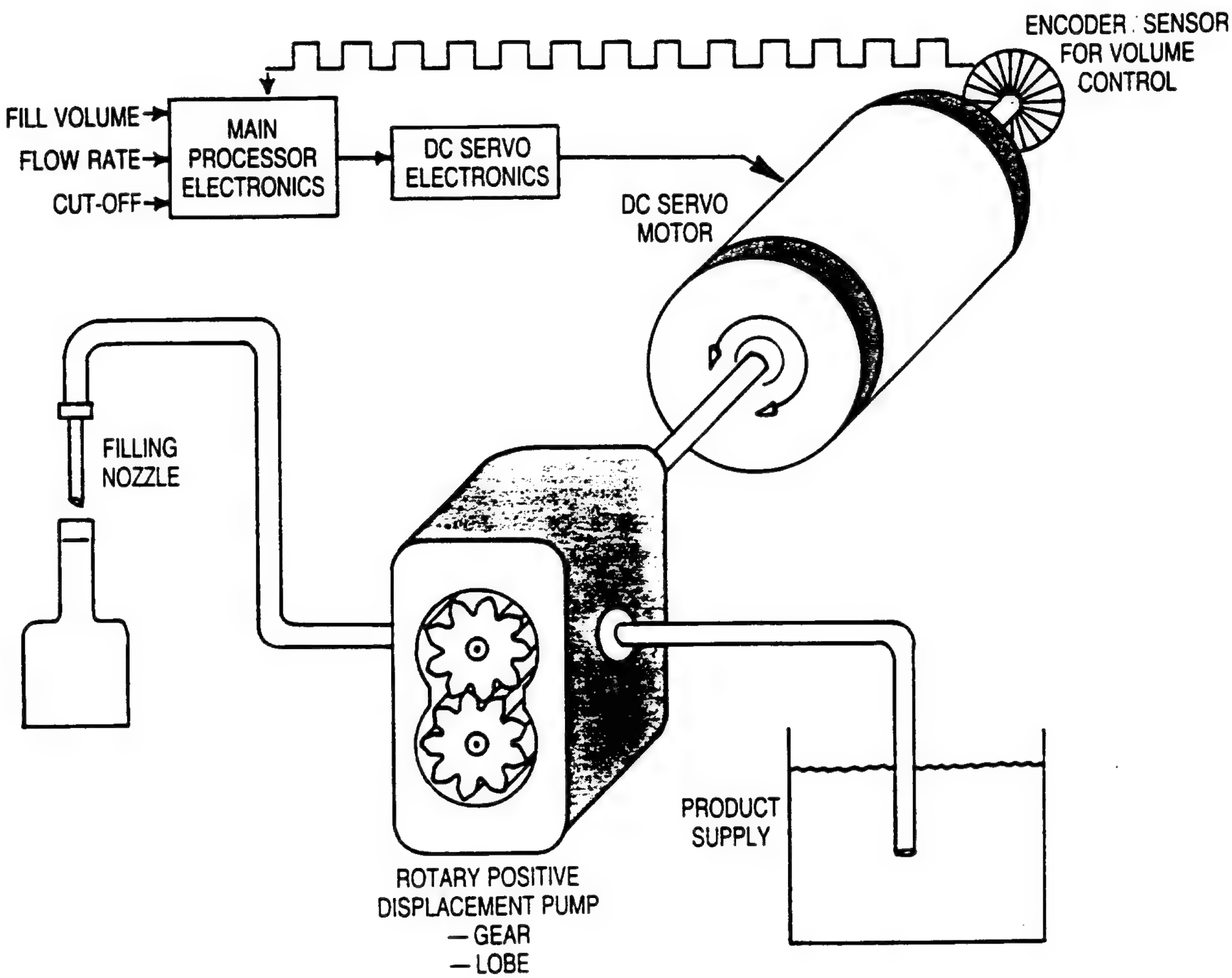
   Again, because of modular construction any filler can be set up and run independently as a benchtop filler anywhere in your facility. If a filler is removed the ones remaining on the stand can be used in any combination.

HOW ODEN FILLERS WORK

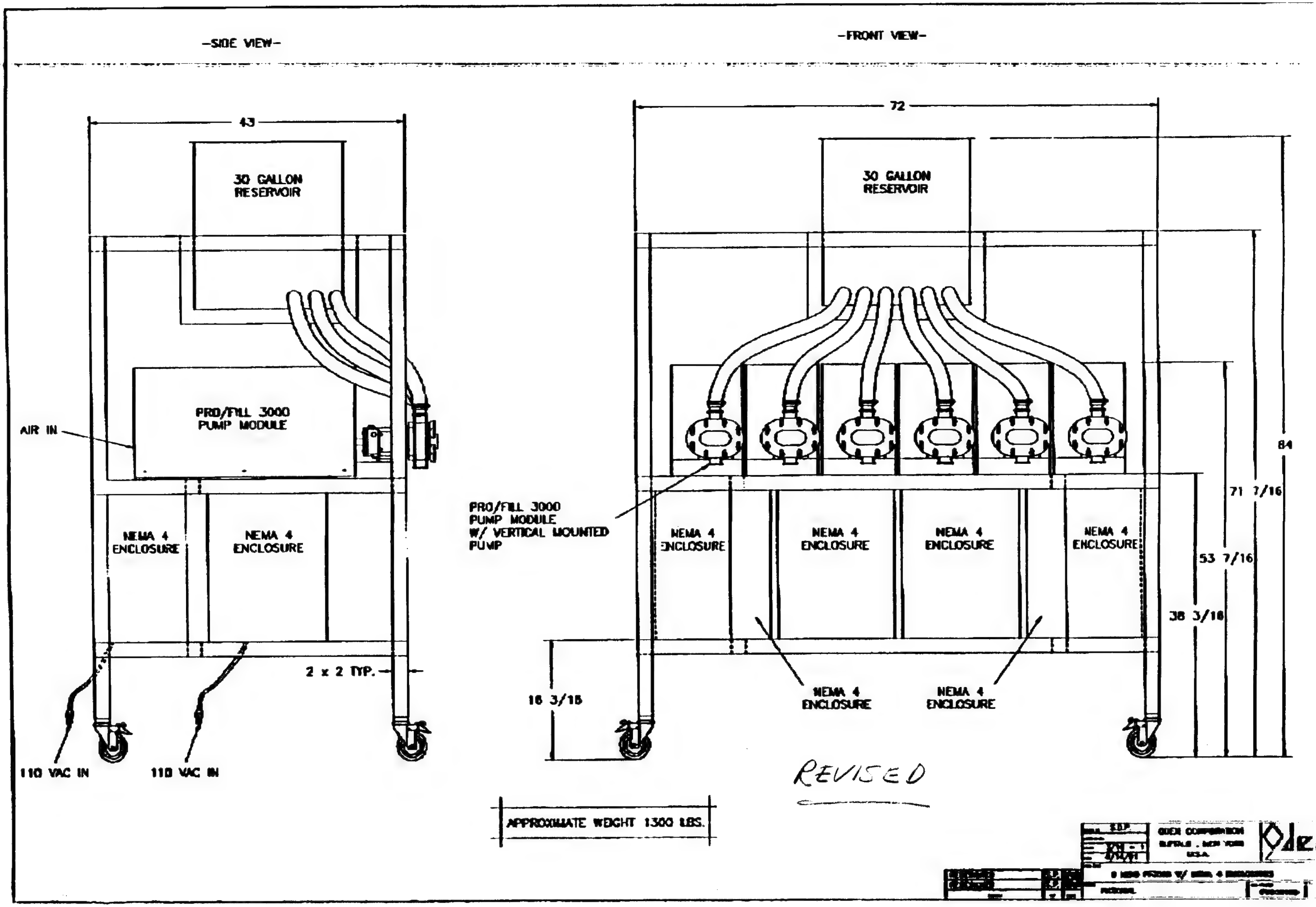
HOW PRO/FILL LIQUID FILLING SYSTEMS WORK

The operation of PRO/FILL systems is based on the use of electronic control of rotating motion positive displacement pumps. These pumps are directly coupled to a DC servo motor. The motor is precisely controlled via digital encoder electronics which allows the pump to turn a pre-selected number of pulses. The exact number of pulses selected will determine the fill volume; the larger the number, the higher the volume. This system permits the selection of fill volume electronically.

The use of DC servo electronics allows the pump to reverse direction at the end of the fill for product suck-back (5000 series) for drip control. DC servo electronics also obsoletes the use of a clutch drive and brake with the PRO/FILL system. This insures high filling precision and long term stability and reduces the moving mechanical wear parts in a PRO/FILL system to 4 per head, far fewer than in less advanced systems.



ODEN CORPORATION • 255 Great Arrow Avenue • Buffalo, N.Y. 14207 • Telephone (716) 874-3000


-SIDE VIEW-
-FRONT VIEW-
43
72
84
71 7/16
53 7/16
38 3/16
16 3/16
30 GALLON RESERVOIR
30 GALLON RESERVOIR
PRO/FILL 3000 PUMP MODULE
PRO/FILL 3000 PUMP MODULE W/ VERTICAL MOUNTED PUMP
AIR IN
NEMA 4 ENCLOSURE
2 x 2 TYP.
110 VAC IN
110 VAC IN
REVISED
APPROXIMATE WEIGHT 1300 LBS.

ODEN CORPORATION • 255 Great Arrow Avenue • Buffalo, NY 14207 • Telephone (716) 874-3000 • FAX (716) 874-1589

January 23, 1992

Mr. Michael H. Dunn
Rutgers - The State University of New Jersey
University Procurement and Contracting
P. O. Box 6999
Piscataway, NJ 08855-6999

RE: Addendum #1 to Oden Quotation #11107
Liquid (Gravy/Sauce) Filling Machine
Per Rutgers RFP #1-5-30-2

Dear Mr. Dunn:

The following changes in this Addendum are the result of extensive discussions and exchanges between Ted Descovich and Neal Litman of CAFT/CRAMTD and the Oden Corporation. The result is a more efficient system than previously quoted to fulfill the specified requirements at a reduced price.

1. Section A. Machine Model - "Six (6)" to be changed to "Three (3)".

2. Section A. Machine Model - Fillers - "Six (6)" to be changed to "Three (3)".

3. Section A. Machine Model - Item #3 - "12" to be changed to "6".

4. Section A. Machine Model - Item #3h. - delete. Insert to now read: "Size: 2" O.D. with 1" I.D. orifice."

5. Section A. Machine Model - Item #7 - delete. To now read: "Each filler to be provided with a fiber optic sensor and mounting hardware for use on the tray line. Each fiber optic sensor will trigger a corresponding filler when the leading edge of a tray is detected. Actual filling can be electronically delayed from 0 to 3 seconds. One filler provided for each of three consecutive tray locations. Each tray is successively filled (step filled) as it passes each filler. Since each filler is triggered discretely when filling the trays, no fill will take place in the event no tray is detected in any one of the filing locations.

6. Section A. Machine Model - Item #8 - delete. To now read: "The three fillers will be linked through a single integration module. A switch on the integration module will determine whether the system is to be used on the tray line or the pouch line. When selected for the tray line, each filler will act discretely as described in revised Section A.7. When selected for the pouch line, the trigger inputs and end-of-fill outputs from each filler are combined to act as a single filling system. The sequence of events will be as follows:

   a. Pouch machine makes switch closure to trigger fillers.
   b. System selects the three nozzles located over three pouches in Row A and fill occurs.
   c. System then selects the three nozzles located over three pouches in Row B and fill occurs.
   d. System offers DC SSR end-of-fill output to pouch machine.
   e. System resets and waits for next fill command from pouch machine.

7. Section A. Machine Model - Item #9. The end-of-fill output signal will be implemented via a DC SSR transistor output.

ODEN CORPORATION • 255 Great Arrow Avenue • Buffalo, NY 14207 • Telephone (716) 874-3000 • FAX (716) 874-1589

8. Section A. Machine Model - Item #13. Reservoir to be 33 gallon low pressure jacketed with three 1.5" tri-clamp feed ports.

9. Section B. Optional Features and Specifications - Item #1 to be included as standard equipment.

10. Section B. Optional Features and Specifications - Item #2. This option is not required due to the changes implemented in Sections A.7 and A.8.

11. Section B. Optional Features and Specifications - Item #3. This option is not required due to the changes implemented in Sections A.7 and A.8.

12. Section B. Optional Features and Specifications - Item #3. Agitation system to be Oden designed variable speed mixer.

13. Section G. Price - Delete. Should now read:

Three (3) Head PRO/FILL 3000 Liquid Filler	$94,300.00

Optional Features:

B-4 Reservoir Agitation System	5,700.00

NOTE: All prices subject to 10% educational discount.

Very truly yours,

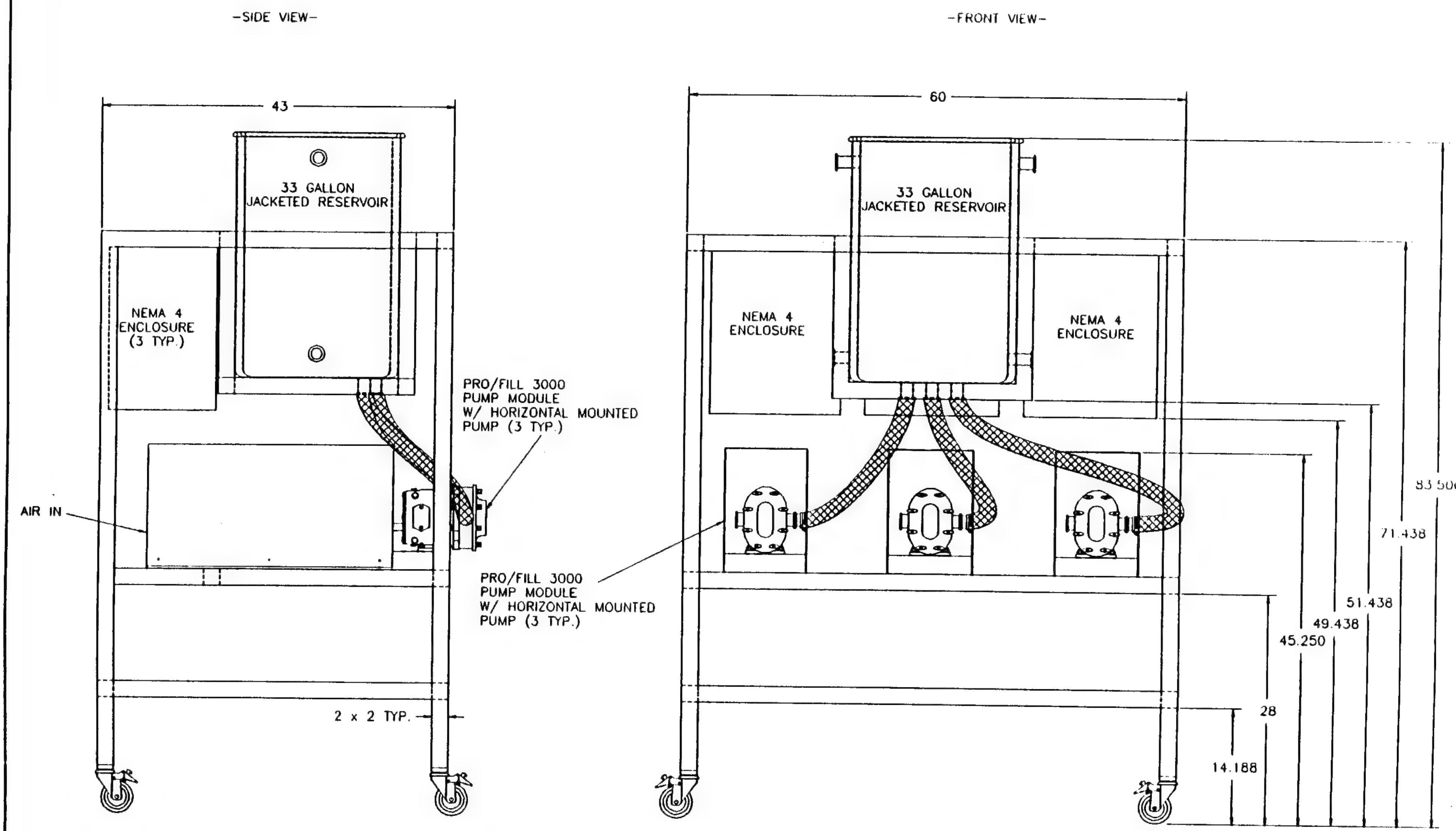
ODEN CORPORATION

Joel C. Slazyk

Joel C. Slazyk
Technical Sales

CC: DAVID RUMBL
CANDACE GRACE

JCS:jm



APPROXIMATE WEIGHT 1300 LBS.

SDP
3/16 = 1
6/14/91
REDESIGNED S.P.
REDESIGNED S.P.
REDESIGNED

ODEN CORPORATION
BUFFALO, NEW YORK
USA

3 HEAD PF3000 W/ NEMA 4 ENCLOSURES RUTGERS

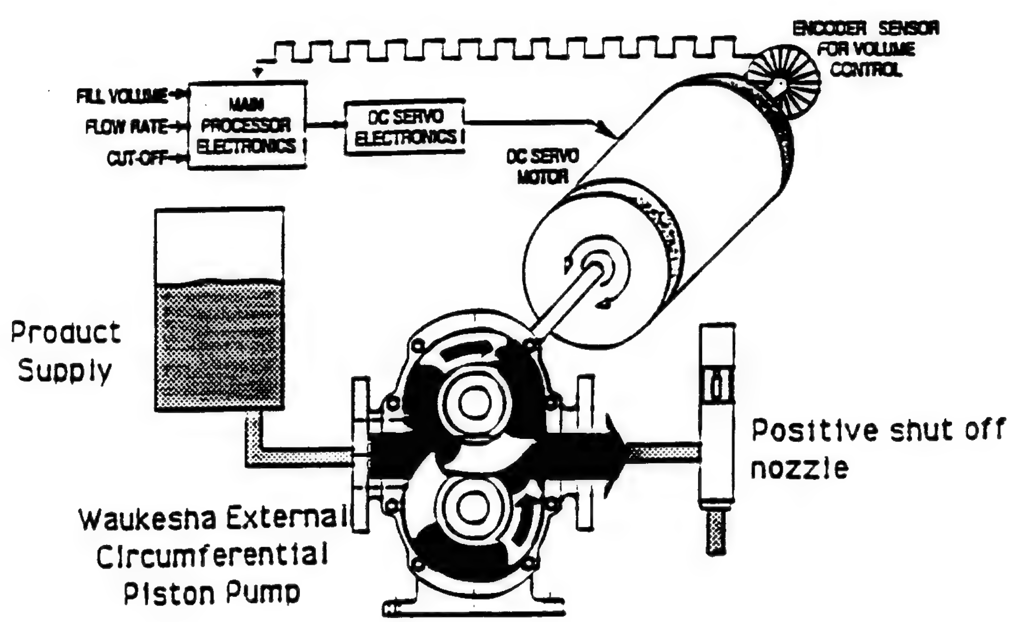
Combat Ration Advanced Manufacturing Technology Demonstration (CRAMTD)

Operation: Automated Filling Systems

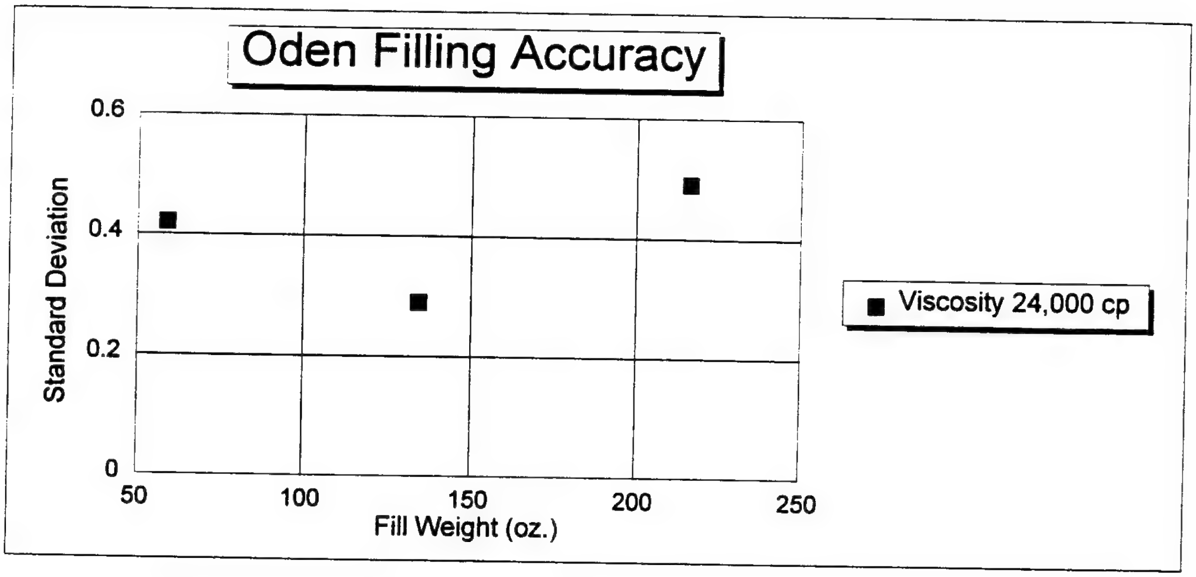
Equipment: Electronic Motor/Pump Filling System (Oden)

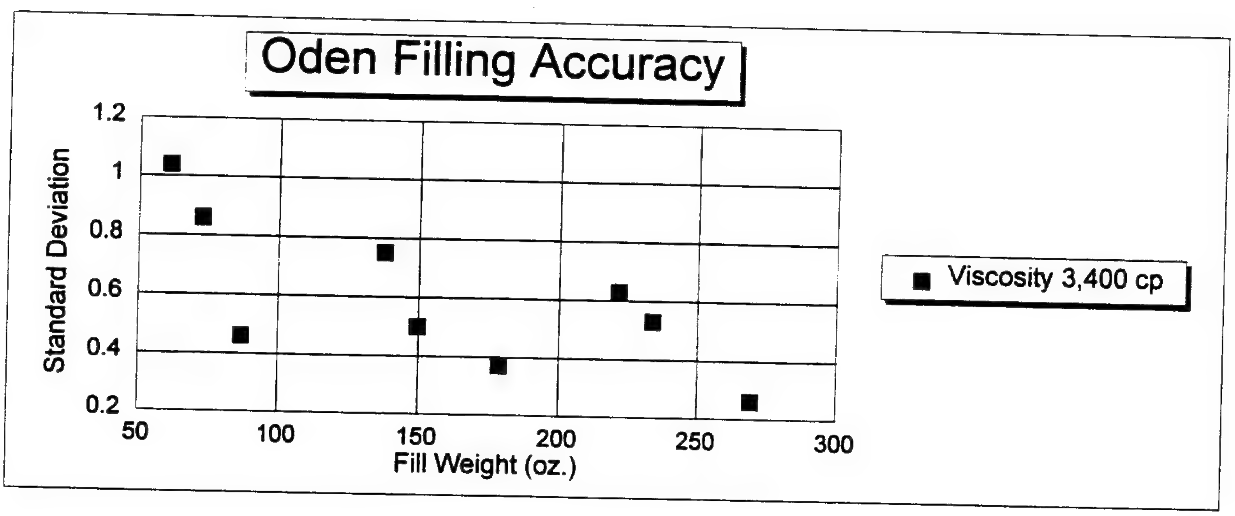
Characteristics/Advantages:

- Handles wide filling range and different products with a single machine
- Modular construction for flexibility
- Higher filling rates than piston fillers
- Use of "smart nozzles" - positive shut off and precise control
- Filling volume and flow rate are electronically controlled
- System can be arranged to fill either 8 oz MRE pouches or the 106 oz half steam table tray, using 3 pumps and 6 nozzles



4.4.4


Oden Filling Accuracy
Standard Deviation
0.6
0.4
0.2
0
50
100
150
200
250
Fill Weight (oz.)
Viscosity 24,000 cp


Oden Filling Accuracy
Standard Deviation
1.2
1
0.8
0.6
0.4
0.2
50
100
150
200
250
300
Fill Weight (oz.)
Viscosity 3,400 cp

Oden Filler Accuracy

Viscosity *	Pump Volume	Pump Speed	Fill Wt. (oz)	Std. Dev.
Hi	290	15	58.68	0.42
Lo	290	15	60.87	1.04
Lo	290	30	72.41	0.86
Lo	290	75	86.66	0.46
Hi	700	15	134.39	0.29
Lo	700	15	137.56	0.75
Lo	700	30	149.46	0.50
Lo	700	75	178.42	0.37
Hi	1150	15	216.19	0.49
Lo	1150	15	221.38	0.63
Lo	1150	30	233.63	0.53
Lo	1150	75	269.34	0.26
* Lo = 3,400 cp				
Hi = 24,000 cp				

Appendix 4.5
Vegetable Filling

12/12/91 4.5.1

RFP# 1-12-1.0-1

FEMC

The State University of New Jersey

RUTGERS

Cook College - Center for Advanced Food Technology

CRAMTD Program

Specifications

for

ROTARY VOLUMETRIC FILLING MACHINE

This specification covers the requirements for an rotary volumetric filling machine that will be used for the CRAMTD Program under STP #2 - Filling Systems for Combat Rations and Other Food Processes.

The machine will be used for the CRAMTD program demonstration site and for research and development of new packaging methods and materials.

This specification consists of the following sections.

1. Performance Requirements
2. Food Product Information
3. Package Information
4. Design Requirements
5. General
6. Acceptance
7. Shipping and Installation

1.0 Performance Requirements

1.1 Operational Duty. The equipment is to be capable of continuous operation in a typical food production environment. The equipment is to be reliable with a Minimum Operating Efficiency of 98%. Minimum Operating Efficiency is defined as percentage of time which equipment performs at specified rate and accuracy. This equipment must operate in a typical washdown area and must withstand the use of non-caustic detergent, bleach and high pressure water cleaning. Cleaning time will be provided daily as required by regulatory agencies (i.e. FDA, USDA) or at least once per day.

1.2 Container Filling. The filler will deposit product into cups which are being conveyed to a cup dumping station. The filler should be capable of

handling a larger cup with a minimum of change parts. Cups presented to the filler may be randomly spaced.

1.3 Filling Rate. The equipment shall be capable of at least 102 standard cups or 40 large cups per minute.

1.4 Food Products. Filling equipment must meet Performance Requirements for food products specified in 2.0 Food Product Information. The filler is to handle food products without excessive damage.

1.5 Fill Volume. The equipment will fill up to 8 ounces per standard cup and up to 50 ounces per optional large cup The equipment will be capable of delivering the following accuracies, when thawed but not greater than 40 degrees F:

2.0 oz. Mixed vegetables (3/8") within +/- 5% by weight.
35 oz. Mixed vegetables (3/8") within +/- 5% by weight for optional large cup.

2.0 Food Product Information

The equipment must be capabable of filling the following:

2.1 Typical food products will be:
- Diced Vegetables 3/8"
- Carrot - pieces, slices
- Potato - slices, chunks
- Mixed vegetables
- Beans dry
- Peas, corn
- Berries

2.2 Fill temperatures from 0F to 180F.

2.3 Foods product may be frozen, thawed, delicate, dry, dehydrated, or wet.

3.0 Container Information

3.1 The equipment will fill standard cups; 2.875" OD x 2.375" ID x 5.5" high. The cups will be on a conveyor which is approximately 36.5" above the floor.

3.2 As an option, the equipment will fill larger cups; 6.625" OD x 6.125" ID x 5.5" high. The cups will be on a conveyor which is approximately 48" above the floor.

4.0 Design Requirements

4.1 Mechanical. Vendor to define mechanism and all necessary equipment. The filler may be provided with an adjustable dial angle as an option. Portion cups are to be interchangable. Filling equipment is to include a hopper suficient for 50 pounds of product. Refer to Drawing "A" for container feed. The filler will be provided with a motor drive.

4.2 Pneumatic service up to 100 PSI. Vendor to specify pneumatic requirements.

4.3 Electrical. Voltage: 220V, 208V or 120V, single or 3 phase. Vendor to specify power requirements. All wiring, connections, control boxes, enclosures and components shall conform to NEMA 4 standards.

4.4 Controls. The equipment will be operated automatically when cups are available at the filler infeed. This may be accomplished with a "no cup - no fill" or a filler stop/start feature.

4.5 Construction. The equipment is to be mounted on castors and height adjustment, if needed, to provide for easy alignment to the filling station as defined by Drawing "A". USDA requirements for food handling equipment apply. Exterior of equipment may be stainless steel, metal covered with USDA approved white epoxy paint and anodized or coated aluminum.

4.6 Physical dimensions, including location of utility hook-ups and weight of the equipment are to be provided.

4.7 Cleanability. Vendor will make every effort to design equipment for easy cleaning, both internally and externally, and to be free from crevices.

4.8 Safety. Vendor will design filling equipment that is safe to operate. Applicable OSHA regulations must be observed.

4.9 Engineering Features. Settings for fill volume should be easily readjusted and reproducible.

5.0 General

5.1 Cost. The proposal is to include total cost F.O.B. Rutgers University, Food Science Building, Cook College, New Brunswick, NJ. Cost of optional equipment, recommended spare parts and accessories should be quoted but clearly delineated from base bid.

5.2 Delivery Schedule. The vendor will specify engineering design, fabrication, testing and delivery schedule.

5.3 Service. The vendor will provide service as needed to fulfill requirements of the warranty and these specifications.

5.4 Manuals. Equipment operational procedure and maintenance will be fully documented in a set of manuals.

5.5 Drawings, Photos. A layout drawing of this machine shall be provided in both plan and elevation views. Photos shall be provided as needed.

5.6 Award. The criteria for selecting a proposal will be based on the evaluation of the CRAMTD staff:

Delivery
Performance
Engineering Features
Cost
Service
Training

5.7 Exceptions. The vendor is to clearly identify any exceptions taken from these specifications.

5.8 Warranty. The vendor warranties the equipment performance specified herein for one year from the date of acceptance.

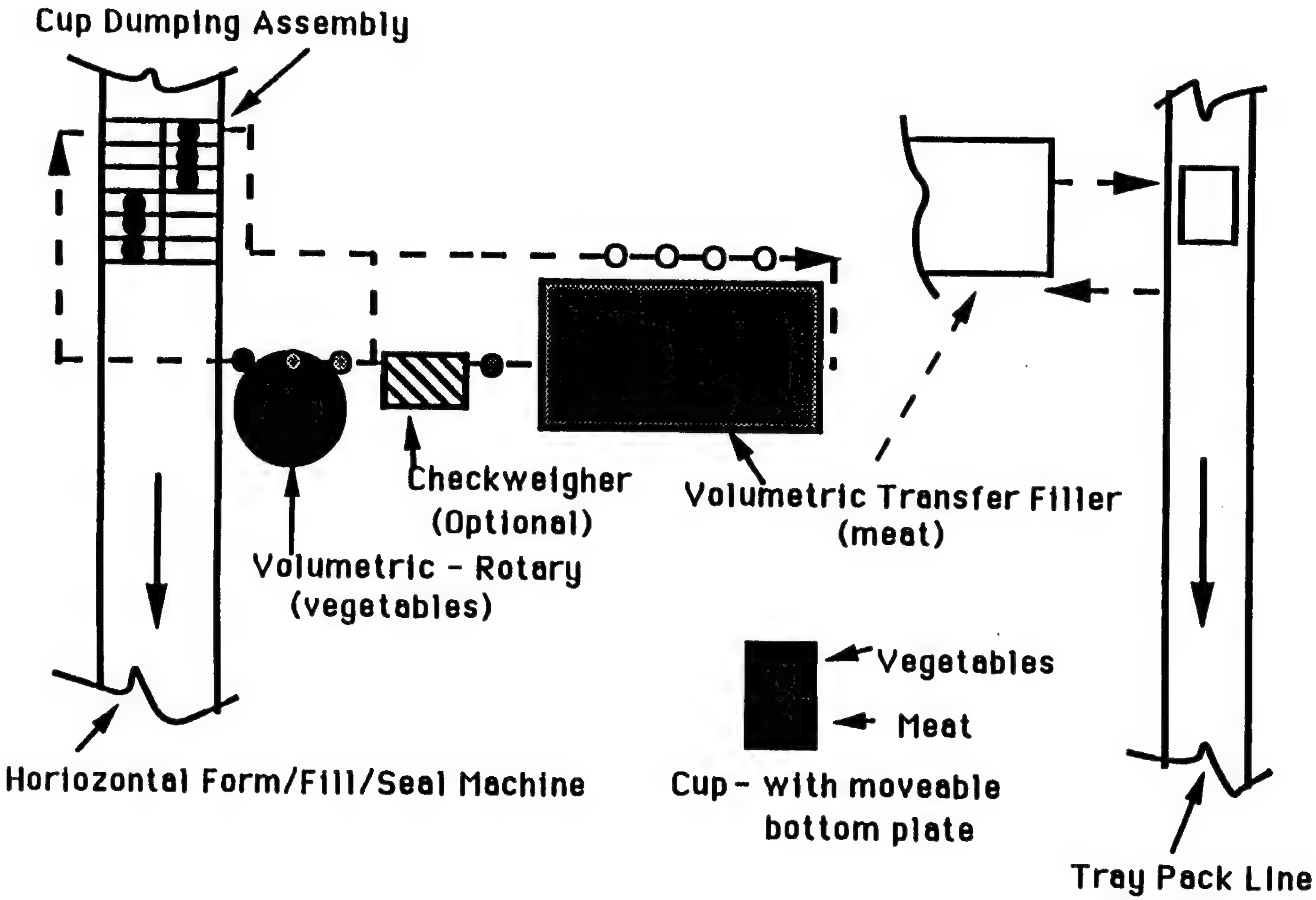
6.0 Acceptance

Acceptance Test. The equipment will be subject to an Acceptance Test to determine whether performance requirements have been met. The equipment will fill cups for one hour at 100 cups per minute. Random samples will be taken and measured for accuracy of fill volume.

7.0 Shipping and Installation

7.1 The equipment will be shipped F.O.B., Rutgers University, Food Science Building, CAFT, Cook College, New Brunswick, NJ 08903.

7.2 The vendor will assemble and install equipment in full working order and provide training to Rutgers personnel in the operation and maintenance of the equipment.



Cup Dumping Assembly
Checkweigher
(Optional)
Volumetric Transfer Filler
(meat)
Volumetric - Rotary
(vegetables)
Vegetables
Meat
Horiozontal Form/Fill/Seal Machine
Cup - with moveable
bottom plate
Tray Pack Line

FIGURE "A"

12/12/91

Vendors for STP# 2 - Rotary Volumetric Filling Equipment

Spee-Dee Packaging Machinery, Inc.
P.O. Box 656
Sturtevant, WI 53177
Attn:David Navin
414 886-4402

Food Equipment Manufacturing Corporation
16900 Rockside Road
Maple Heights, OH 07004
Attn: Scott Burrows
216 663-1208

Raque Food Systems, Inc.
P.O. Box 99416
11002 Decimal Drive
Louisville, KY 40299
Attn: Jack Hayden
502 267-9641

FEMC
FOOD EQUIPMENT
MANUFACTURING CORPORATION

22201 Aurora Road
Bedford Heights, Ohio 44146
Tel: (216) 663-1208
Fax: (216) 663-9337
Tlx: 980131 WDMR

February 13, 1992

Mr. Ted Descovich
Rutgers, The State University of New Jersey
Cook College
P.O. Box 231
New Brunswick, NJ 08903-0231

Dear Ted:

Pursuant to our recent conversation, enclosed is a revised quotation reflecting a change of reduction in service and installation cost and to the set of spare parts.

Looking forward to receiving a quotation in the near future.

If you have any questions please do not hesitate to call.

Very truly yours,

Michael J. Mortier

Michael J. Mortier
Sales Engineer

MJM:bb
Encl: Quote #5089

FOOD EQUIPMENT MANUFACTURING CORPORATION
22201 Aurora Road
Bedford Heights, OH 44146
(216) 663-1208

5089

TO: Rutgers, The State University (Company) P.O. Box 231 (Street) New Brunswick, NJ 08903-0231 (City, State, Zip Code)

Attention: Theodore Descovich

Gentlemen:

1. We, FOOD EQUIPMENT MANUFACTURING CORPORATION ("F.E.M.C."), an Ohio corporation, will sell and deliver to you, F.O.B. shipping point to the premises designated by you at same as above the following specified equipment in accordance with the specifications, terms, and conditions stated herein and/or accompanying and made a part hereof.

2. DESCRIPTION | SPECIFICATIONS

1 ANGULAR DIAL FILLER WITH DRIVE AND SCREW LOCATOR
(Preferred vendor price) $65,515.00

The dial plate is 1" thick acrylic with machined step to accept various size inserts to dispense a wide range of products. the frame is constructed of 2" x 2" tubular stainless steel continuously welded and glass bead blasted. One set of stainless steel inserts and a round hopper with spring loaded product guide is included. A stainless steel Nema 4X panel box will house all electrical controls and frequency drive system, high/low detection and no bowl detection. The base system will be designed on a 36 1/2" working height off the floor. The angular dial filler will be centrally controlled by an Allan Bradley PLC (model # to be determined) to interface all electric eye's and control the servo motor for fill volume level control. A small container screw locator will be fixed line mounted and driven off the 2 Hp variable frequency drive system mounted on the frame of the dial filler.

1 SHIPPING $1,200.00

1 SERVICE AND INSTALLATION $6,000.00

Estimated costs for 1 men x 40 hours per week for one week cost to include travel, food & lodging,a car rental and travel hours and service hours. (This price will include training).

3. **PURCHASE TERMS AND TERMS OF PAYMENT.**
The purchase price for the equipment and installation as herein specified, F.O.B. shipping point, is: $ continued on next page
payable in United States current funds at par as follows:

Terms: Thirty per cent (30%) of the value of the equipment and material shall be paid by Buyer upon acceptance of this order by F.E.M.C.;
Thirty per cent (30%) shall be paid upon notification to Buyer that the equipment has reached mid-construction;
Thirty per cent (30%) shall be paid upon notification to Buyer that the equipment is ready for shipment; and
The balance of ten per cent (10%) shall be paid thirty (30) days after receipt by Buyer, and installation of the equipment at Buyer's premises.
Overdue payments are to bear interest at the highest legal rate.
Terms of payment shall not be affected should the equipment be damaged or destroyed after delivery at the site of the installation, whether by fire, the elements, or otherwise.

Delivery: All times stipulated herein for manufacturing and delivery of any equipment or machine shall commence from the date of receipt by F.E.M.C. of the initial dov payment referable to the particular equipment or machine.

The additional specifications, terms and conditions incorporated herein appear in Paragraphs 4 through 17 (over), and accompany and are made a part hereof.

FOOD EQUIPMENT MANUFACTURING CORPORATION

By:

BUYER'S ACCEPTANCE:

Approved at:

Date:

Date: February 12, 1992

COMPANY:

By:

FOOD EQUIPMENT MANUFACTURING CORPORATION
22201 Aurora Road
Bedford Heights, OH 44146
(216) 663-1208

TO: Rutgers, The State University P.O. Box 231 New Brunswick, NJ 08903-0231
Company Street City, State, Zip Code

Attention: Theodore Descovich

Gentlemen:

1. We, FOOD EQUIPMENT MANUFACTURING CORPORATION ("F.E.M.C."), an Ohio corporation, will sell and deliver to you, F.O.B. shipping point to the premises designated by you at same as above
the following specified equipment in accordance with the specifications, terms, and conditions stated herein and/or accompanying and made a part hereof.

2.	DESCRIPTION	SPECIFICATIONS
	Options:	
1	AUTOMATIC LIFT ASSEMBLY	$7,000.00
	To automatically adjust between 36 1/2" height of the pouch conveyor to 48" height of the tray pack line. Include 2 position switch for height selection.	
1	SET OF INSERTS FOR LARGE CONTAINER	$3,000.00
1	LARGE SCREW INFEED LOCATOR	$9,200.00
	This unit will be fixed line mounted and driven off the 2 Hp variable frequency drive system mounted on the frame of the dial filler.	
1	SET OF SPARE PARTS	$2,800.00
	Delivery is 90 days from receipt of purchase order.	
	Shipping, Service and Installation is included in quotation.	

3. PURCHASE TERMS AND TERMS OF PAYMENT.
The purchase price for the equipment and installation as herein specified, F.O.B. shipping point, is: $ 72,715.00 (not including options) payable in United States current funds at par as follows:

Terms: Thirty per cent (30%) of the value of the equipment and material shall be paid by Buyer upon acceptance of this order by F.E.M.C.;
Thirty per cent (30%) shall be paid upon notification to Buyer that the equipment has reached mid-construction;
Thirty per cent (30%) shall be paid upon notification to Buyer that the equipment is ready for shipment; and
The balance of ten per cent (10%) shall be paid thirty (30) days after receipt by Buyer, and installation of the equipment at Buyer's premises.
Overdue payments are to bear interest at the highest legal rate.
Terms of payment shall not be affected should the equipment be damaged or destroyed after delivery at the site of the installation, whether by fire, the elements, or otherwise.

Delivery: All times stipulated herein for manufacturing and delivery of any equipment or machine shall commence from the date of receipt by F.E.M.C. of the initial down-payment referable to the particular equipment or machine.

The additional specifications, terms and conditions incorporated herein appear in Paragraphs 4 through 17 (over), and accompany and are made a part hereof.

BUYER'S ACCEPTANCE:

Date: ________

COMPANY: ________

By: ________

FOOD EQUIPMENT MANUFACTURING CORPORATION

By: ________

Approved at: ________

Date: February 12, 1992

By: ________

FEMC
FOOD EQUIPMENT
MANUFACTURING CORPORATION

22201 Aurora Road
Bedford Heights, Ohio 44146
Tel: (216) 663-1208
Fax: (216) 663-9337
Tlx: 980131 WDMR

February 3, 1992

Mr. Ted Descovich
Rutgers The State University of New Jersey
University Procurement & Contracting
Administrative Services Annex Bldg. Room 101
Davidson Road/Busch Campus
Piscataway, NJ 08855

Dear Ted:

Pursuant to your request for a volumetric filler and subsequent meeting at FEMC, enclosed is a proposal for your review.

I have broken the system down to a basic system for your horizontal form/fill seal machine, with options for filling the larger tray pack containers.

This proposal outlines the system as we interpret your needs from specifications forwarded to FEMC.

FEMC sincerely appreciates participation in this project and feel comfortable in our ability to successfully complete it to your satisfaction.

If you have any questions, please do not hesitate to call Scott Burrows or myself.

Very truly yours,

Michael J. Mortier
Sales Engineer

MJM:bb
Enclosures

FEMC PROPOSAL FOR

RUTGERS - THE STATE UNIVERSITY OF NEW JERSEY

RFQ # 1-12-16-1

CRAMTD Program

Tray/Pouch - Volumetric Filler with Options

February 3, 1992

Rutgers Specifications CRAMTD Program

Performance Requirements - FEMC volumetric filler

1.1 <u>Operational Duty</u>
The FEMC equipment will be capable of continuous operation in a typical food production environment at a 98% operating efficiency with regard to only FEMC equipment. If other associated equipment affect the FEMC dial filler operation, efficiencies will be decreased. eg. Failure to provide a backup of containers to FEMC system or enough product to the filler. The equipment is designed to withstand washdown and is approved by the USDA for use with USDA approved packaging systems.

1.2 <u>Container Filling</u>
The FEMC angular dial filler will deposit into standard cups - 2.875" outside diameter x 2.375" inside diameter x 5.5" high which are being conveyed to the cup dumping station. The system will allow for handling a larger 6.625" outside diameter x 6.125" inside diameter x 5.5" high with minimal change parts. These optional parts will include a new set of inserts to allow for filling a larger insert, new timing screw as well as a filler lifting system to allow for the higher tray pack machine. The cups presented to the FEMC system will be backed up significantly to allow the dial filler to cycle on and off to achieve a no cup/no fill option.

1.3 <u>Filling Rate</u>
The FEMC angular dial filler will be capable of filling at 102 cups per minute. The optional change and parts will allow filling 40 large cups per minunte.

1.4 <u>Food Products</u>
See section 2.0 food product information.

1.5, 2.0., 2.1 <u>Fill Volume</u>
The fill volumes will fill up to 80 ounces per standard cup for the small pouch of mixed vegetables 3/8" designed for 2 ounces of vegetables and up to 50 ounces for the optional large cup with the accuracy of +/- 5% by weight. <u>Various inserts will be required to dispense the full range of products. Specific gravity (weight per volume) will be required for each product.</u>

2.2 - 2.3
Fill temperatures product will be run thawed but no greater than 40 degrees faranheit. It is anticipated that the temperature will be less than 40 degrees faranheit, FEMC understands that temperatures may vary from 0-180 degrees faranheit. Various products may require additional equipment to allow for various temperatures and product consistency. Further parameters or product temperature and consistency will be required to determine any additional equipment that will be required.

3.0, 3.1, 3.2 Container Information
The equipment will fill standard cups 2.875" outside diameter x 2.375" inside diameter x 5.5" high as shown from sample brought to FEMC engineering meeting. The height of the conveyor will be 36.5" above the floor(Solbern transitional cup insert and dumping machine).

An optional system will fill a large cup 6.625" outside diameter x 6.125" inside diameter x 5.5" high. Container is similar to the cup as discussed in engineering meeting per your visit. The height of the conveyor is 48" above the floor. Conveyor drawings will be required prior to building system.

4.0 Design Requirements
The FEMC angular dial filler will have a hopper sufficient for 50 pounds of mixed vegetables. The dial filler bottom now adjustable dead plate and top revolving insert plate will allow individual inserts to interchange to allow for varying fill weight ranges. The telescoping plates will allow for adjusting the weight ranges with one adjusting servo motor. This one machine will interface with the Solbern transitional cup insert and dumping machine. A 2 Hp variable frequency drive system will drive the timing screw and angular dial filler. A clutch system will allow for the dial and indexing screw to stop when no backup of containers are present and will achieve a no cup/no fill option.

4.2 - 4.3 Electric and Air Requirements
Equipment will require 80 PSI pneumatic service. Electrical voltage will be 220 3 phase. All electrical equipment will conform to Nema 4 standards and enclosed in a Nema 4X stainless steel enclosure.

4.4 & 4.9 Controls and Engineering Features
All FEMC equipment is designed to be operated in the automatic control mode. Containers will be backed up at the infeed side of the screw locator. Electric eye's will signal the filler to deposit mixed vegetables until a backup of containers are not present prior to the timing screw.

In a no backup situation the dial filler will ramp down to accommodate delivery of containers to the dial filler until FEMC receives a backup or normal situation providing containers at a 102 cpm pace. If the electric eye prior to the screw locator has no containers present the dial filler and screw locator will stop until appropriate backup of containers are present for normal operation.

The adjustment for the dial plate will be done with a servo motor allowing for automatic adjustments with a push of a button.

4.5 Construction
Equipment will be mounted on locking casters and will be adjustable from 36.5 inches to 48 inches above the floor with the optional automatic lift assembly. Actual heights must be furnished prior to design. FEMC equipment is designed to withstand washdown and will be approved by the USDA for use with USDA approved packaging systems.

4.6 Physical Dimensions
Approximate dimensions and utility hookups are provided on enclosed sales drawing #S-405.

4.7 Cleanability
Complete system will be designed for quick removal and dismantling for ease of cleaning.

4.8 Safety
The system will be guarded to acceptable OSHA requirements.

COST

5.1
The price minus options include delivery F.O.B. Rutgers University, Food Science Building, Cook College, New Brunswick, NJ. Spare parts lists will be provided prior to shipment to Rutgers University. Typical costs for spare parts are 7-10%, these are optioned out for you on the quotation (Ballpark priced).

5.2 Delivery
90 days from receipt of purchase order and down payment.

5.3 Service and Training
Shall be provided as required to fulfill the requirements of the warranty.

5.4 Manual
Equipment operational procedures as well as required maintenance schedule will be documented in two manuals.

5.5 Drawing
See attached drawing (S-405) for plan and elevation of the proposed angular dial filler.

5.8 Warranty
FEMC will warranty the FEMC angular dial filler for 1 year as documented on the back of quotation #

6.0 Acceptance Tests
FEMC angular dial filler will fill the Solbern small 2 to 8 ounce cups for 1 hour at 100 cups per minute. The dial filler will be capable of delivering the accuracies when the product is thawed but not greater than 40 degrees faranheit.

Rutgers Specifications - CRAMTD Program

<u>Item - Product</u>	Diced vegetables 3/8" cubed Carrot - pieces, slices Potato - slices, chunks Mixed vegetables Dry beans Peas, corn Berries

Designed for 2 ounce fill to 8 ounce fill (small cup)
optional 35 ounce to 50 ounce fill (large cup)

Speed 102 cpm - small cups
40 cpm - large cups

Physical dimensions - See attached drawing S-405

Electrical Requirements - 220, 3 phase service

Service & Installation: Included in pricing

FEMC

FOOD EQUIPMENT MANUFACTURING CORPORATION
22201 Aurora Road
Bedford Heights, OH 44146
(216) 663-1208

5073

TO: Rutgers The State Univ. of New Jersey (Company) PO Box 6999 (Street) Piscataway NJ 08855 (City, State, Zip Code)

Attention: Theodore Descovich

Gentlemen:

1. We, FOOD EQUIPMENT MANUFACTURING CORPORATION ("F.E.M.C."), an Ohio corporation, will sell and deliver to you, F.O.B. shipping point to the premises designated by you at same as above . the following specified equipment in accordance with the specifications, terms, and conditions stated herein and/or accompanying and made a part hereof.

2. | DESCRIPTION | SPECIFICATIONS

1 ANGULAR DIAL FILLER WITH DRIVE AND SCREW LOCATOR $65,515.00

The dial plate is 1" thick acrylic with machined step to accept various size inserts to dispense a wide range of products. the frame is constructed of 2" x 2" tubular stainless steel continuously welded and glass bead blasted. One set of stainless steel inserts and a round hopper with spring loaded product guide is included. A stainless steel Nema 4X panel box will house all electrical controls and frequency drive system, high/low detection and no bowl detection. The base system will be designed on a 36 1/2" working height off the floor. The angular dial filler will be centrally controlled by an Allan Bradley PLC (model # to be determined) to interface all electric eye's and control the servo motor for fill volume level control. A small container screw locator will be fixed line mounted and driven off the 2 Hp variable frequency drive system mounted on the frame of the dial filler.

1 SHIPPING $1,200.00

1 SERVICE AND INSTALLATION $12,000.00

Estimated costs for 2 men x 40 hours per week for two weeks cost to include travel, food & lodging,a car rental and travel hours and service hours.
(This price will include training).

3. **PURCHASE TERMS AND TERMS OF PAYMENT.**
The purchase price for the equipment and installation as herein specified, F.O.B. shipping point, is: $ continued on next page ,
payable in United States current funds at par as follows:

Terms: Thirty per cent (30%) of the value of the equipment and material shall be paid by Buyer upon acceptance of this order by F.E.M.C.;

Thirty per cent (30%) shall be paid upon notification to Buyer that the equipment has reached mid-construction;

Thirty per cent (30%) shall be paid upon notification to Buyer that the equipment is ready for shipment; and

The balance of ten per cent (10%) shall be paid thirty (30) days after receipt by Buyer, and installation of the equipment at Buyer's premises.

Overdue payments are to bear interest at the highest legal rate.

Terms of payment shall not be affected should the equipment be damaged or destroyed after delivery at the site of the installation, whether by fire, the elements, or otherwise.

Delivery: All times stipulated herein for manufacturing and delivery of any equipment or machine shall commence from the date of receipt by F.E.M.C. of the initial dow payment referable to the particular equipment or machine.

The additional specifications, terms and conditions incorporated herein appear in Paragraphs 4 through 17 (over), and accompany and are made a part hereof.

BUYER'S ACCEPTANCE:

Date:

COMPANY:

FOOD EQUIPMENT MANUFACTURING CORPORATION

By: [signature]

Approved at:

Date: February 3, 1992

By:

22201 Aurora Road
Bedford Heights, OH 44146
(216) 663-1208

TO: Rutgers, The State University (Company) P.O. Box 231 (Street) New Brunswick, NJ 08903-023 (City, State, Zip Code)

Attention: Theodore Descovich

Gentlemen:

1. We, FOOD EQUIPMENT MANUFACTURING CORPORATION ("F.E.M.C."), an Ohio corporation, will sell and deliver to you, F.O.B. shipping point to the premises designated by you at same as above the following specified equipment in accordance with the specifications, terms, and conditions stated herein and/or accompanying and made a part hereof.

2. | DESCRIPTION SPECIFICATIONS

Options:

1 AUTOMATIC LIFT ASSEMBLY $7,000.00

To automatically adjust between 36 1/2" height of the pouch conveyor to 48" height of the tray pack line. Include 2 position switch for height selection.

1 SET OF INSERTS FOR LARGE CONTAINER $3,000.00

1 LARGE SCREW INFEED LOCATOR $9,200.00

This unit will be fixed line mounted and driven off the 2 Hp variable frequency drive system mounted on the frame of the dial filler.

1 SET OF SPARE PARTS – $2,800.00

Delivery is 90 days from receipt of purchase order.

Shipping, Service and Installation is included in quotation.

3. PURCHASE TERMS AND TERMS OF PAYMENT.

The purchase price for the equipment and installation as herein specified, F.O.B. shipping point, is: $ 72,715.00 (not including options payable in United States current funds at par as follows:

Terms: Thirty per cent (30%) of the value of the equipment and material shall be paid by Buyer upon acceptance of this order by F.E.M.C.;

Thirty per cent (30%) shall be paid upon notification to Buyer that the equipment has reached mid-construction;

Thirty per cent (30%) shall be paid upon notification to Buyer that the equipment is ready for shipment; and

The balance of ten per cent (10%) shall be paid thirty (30) days after receipt by Buyer, and installation of the equipment at Buyer's premises.

Overdue payments are to bear interest at the highest legal rate.

Terms of payment shall not be affected should the equipment be damaged or destroyed after delivery at the site of the installation, whether by fire, the elements, or otherwise.

Delivery: All times stipulated herein for manufacturing and delivery of any equipment or machine shall commence from the date of receipt by F.E.M.C. of the initial down payment referable to the particular equipment or machine.

The additional specifications, terms and conditions incorporated herein appear in Paragraphs 4 through 17 (over), and accompany and are made a part hereof.

FOOD EQUIPMENT MANUFACTURING CORPORATION

BUYER'S ACCEPTANCE:

By:

Date:

Approved at:

COMPANY:

Date: February 12, 1992

By:

By:

FEMC PROPOSAL FOR

RUTGERS - THE STATE UNIVERSITY OF NEW JERSEY

RFQ # 1-12-16-1

CRAMTD Program

Tray/Pouch - Volumetric Filler with Options

February 3, 1992

PREAMBLE

This Agreement, entered into on April 15, 1992, by and between Rutgers, The State University of New Jersey with principal offices in New Brunswick, New Jersey (hereinafter called the "University") and Food Equipment Manufacturing Corporation (hereinafter called the "Subcontractor"), and constituting a subcontract under Contract No. DLA900-88-D-0383, from Defense Logistics Agency issued to Rutgers, The State University.

WITNESSETH THAT:

The Subcontractor agrees to perform the work and services set forth in this Agreement for the consideration stated herein.

SCHEDULE

ARTICLE 1. STATEMENT OF WORK

(a) The Subcontractor shall provide the necessary personnel, equipment, facilities, and supplies to perform the work described in the attached Statement of Work, marked Exhibit A, which by this reference is made a part hereof.

(b) The subcontractor shall designate ,as its Project Director, who shall not be removed or replaced without the prior approval of the University.

(c) The University hereby designates Ted Descovich, Rutgers University as the University Project Director for this work.

ARTICLE 2. AGREEMENT PERIOD

(A) The duration of this Agreement shall be 90 days after issuance of Purchase Order, which is estimated to be a period between April 15, 1992 through August 15, 1992, unless terminated earlier as provided herein.

ARTICLE 3. ALLOWABLE PRICE AND PAYMENT

(a) The price for performance under this Agreement during the budget period is $94,715., which may not be exceeded unless changed by written amendment to this Agreement.

(b) The total price is comprised of:

		Price
1.	FEMC Filler	
	a. Angular Dial Filler w/Drive and Screw Locator	$65,515
	b. Shipping	1,200
	c. Service, Installation & Training	6,000
	Sub-Total	$72,715
2.	Options:	
	a. Automatic Lift Assembly	7,000
	b. Large Container Inserts	3,000
	c. Large Infeed Locator	9,200
	d. Spare Parts	2,800
	Sub-Total	22,000
3.	**TOTAL**	**$94,715**

(c) Payment shall be made as follows:

1. Thirty percent (30%) upon placement of order.

2. Thirty percent (30%) when equipment has reached mid-construction.

3. Thirty percent (30%) upon shipment.

4. Balance of ten percent (10%) net 30 days date of invoice after installation and University acceptance of equipment at University's site.

ARTICLE 4. TECHNICAL REPORTS

The Subcontractor shall submit such technical reports to the University's Project Director as required by the University to meet the technical report requirements of the prime agreement. Each report shall be submitted sufficiently in advance of the report deadline to allow review and comment by the University project Director prior to timely transmittal to the funding agency. Monthly progress reports, in a mutually acceptable format, are due by the fifteenth of the following month.

ARTICLE 5. UNIVERSITY AUTHORIZED REPRESENTATIVE

The University's authorized representative is Andrew B. Rudczynski, Ph.D., Assistant Vice President for Research Administration.

ARTICLE 6. SPECIAL PROVISIONS

(a) Title to equipment acquired with subcontract funds shall vest with the University and subject to the rights of the Government.

(b) All persons rendering services covered by this Agreement on behalf of the Subcontractor, including their employees and agents shall be considered to be employees of the Subcontractor for the purpose of any state workers' compensation laws or federal workers' compensation statutes. Subcontractor hereby agrees to indemnify the University against all claims or awards under such workers' compensation laws arising out of this Agreement. The Subcontractor further agrees to hold the University and its employees harmless, and to defend and indemnify them against all claims, actions, liability, damage, loss, and expenses (including attorney's fees) by reason of injury, illness or death to any person or persons or damaged property arising or alleged to have arisen from any negligent or willful act or omission of the Subcontractor, or its employees or agents, arising out of Subcontractor's performance under this Agreement.

(c) This Agreement may not be assigned in whole or in part without the prior written consent of the University.

(d) Subcontractor is free to copyright material developed under or in connection with this Agreement, and shall give notice to the University of any material so copyrighted. If any copyrightable material is developed by Subcontractor, the University shall have a royalty-free, nonexclusive, and irrevocable right to reproduce, publish, or otherwise use, and to authorize others to use, the copyrightable works.

(e) Subcontractor agrees to make any resulting or incorporated technology available to other members of CRAMTD for Commercial use as provided for in the CRAMTD Intellectual Property Policy (Exhibit C).

(f) No publicity matter having or containing any reference to Rutgers or in which the name of Rutgers is mentioned shall be made use of by the Subcontractor until written approval has been obtained from the University.

(g) Any disagreements arising out of this Agreement or from a breach thereof, shall be submitted to arbitration and the judgement upon the award rendered by the arbitrators may be entered in any court having jurisdiction thereof. The arbitration shall be held under the procedures and rules of the American Arbitration Association. Any arbitration shall be held in Newark, New Jersey, unless mutually agreed otherwise.

(h) This Agreement supersedes and replaces any previous arrangements, oral or written between the parties hereto pertaining to this subcontract.

(i) The conditions of this Agreement may be changed at any time by mutual agreement. Said change shall be in the form of a duly executed amendment to this Agreement.

(j) Unless otherwise specifically provided in this Agreement, the quality of all services rendered hereunder shall conform to the highest standards in the relevant profession, trade or field of endeavor. All services shall be rendered by or supervised directly by individuals fully qualified in the relevant professions, trade or field, and holding any licenses required by law.

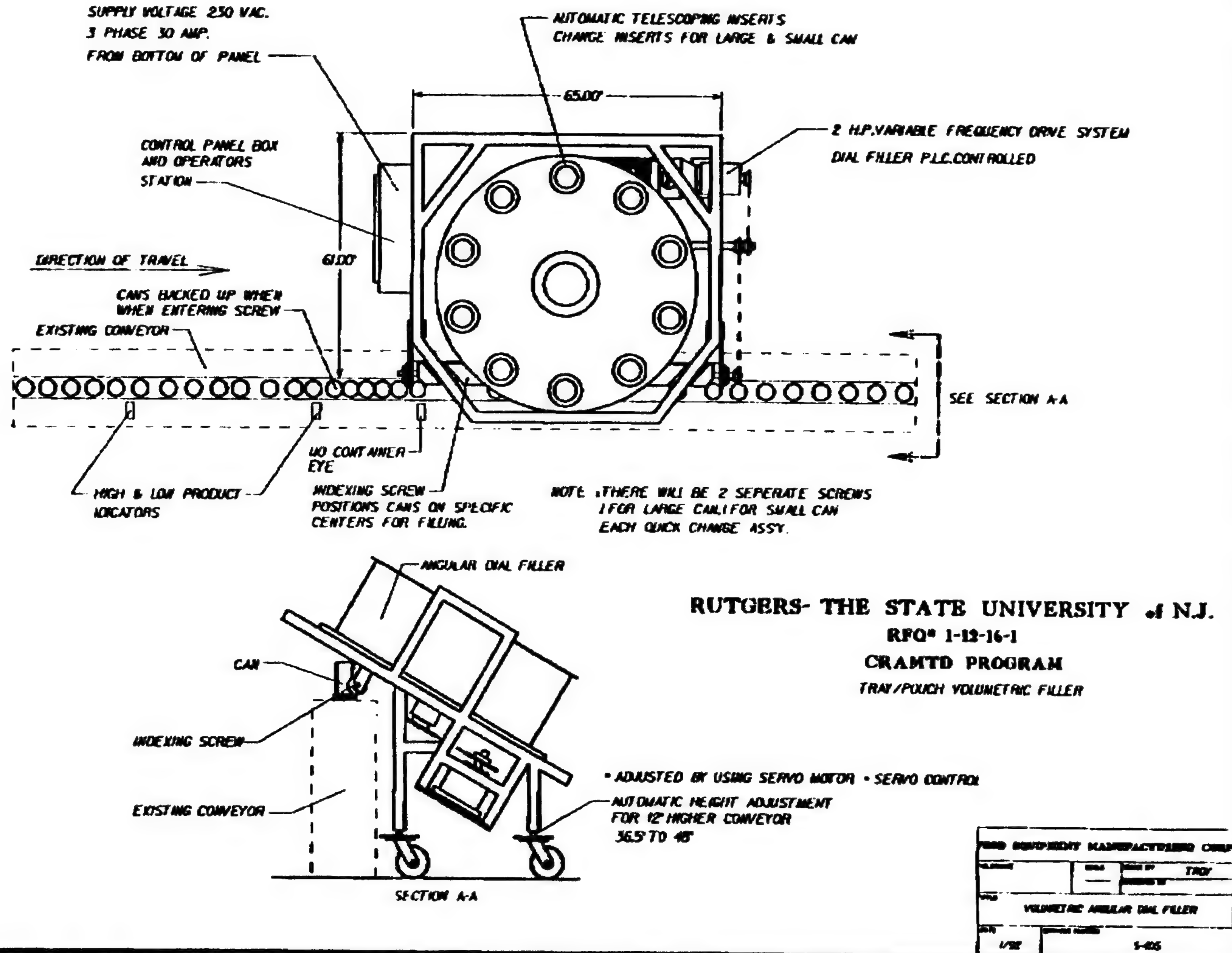
(k) Upon mutual assent, the University or the Subcontractor may advance the termination date of this Agreement by giving the other thirty (30) days notice in writing that this Agreement shall terminate at the specified earlier date. In the event of termination pursuant to this article, the University shall pay to the Subcontractor, in addition to the Subcontractor's invoices then outstanding, all costs and expenses incurred prior to receipt of such notice, plus approved costs expended until the date of termination.

ARTICLE 7. INCORPORATION OF PROVISIONS OF PRIME AGREEMENT

(a) All provisions of the prime agreement, which are applicable to subcontracts are contained in Exhibit B, attached hereto, shall be binding upon the Subcontractor and Subcontractor hereby agrees with same.

IN WITNESS WHEREOF, the University and the Subcontractor have hereunto executed this Agreement as of the month, day and year first above written.

FOOD EQUIPMENT MANUFACTURING CORP.	RUTGERS, THE STATE UNIVERSITY
________________________	________________________ Andrew B. Rudczynski Assistant Vice President For Research Administration
________________________ Date	________________________ Date



RUTGERS- THE STATE UNIVERSITY of N.J.

RFQ# 1-12-16-1

CRAMTD PROGRAM

TRAY/POUCH VOLUMETRIC FILLER

Combat Ration Advanced Manufacturing Technology Demonstration (CRAMTD)

UPDATE

Operation: Automated Filling Systems

Equipment: Angular Dial Volumetric Filling of Solids (FEMC)

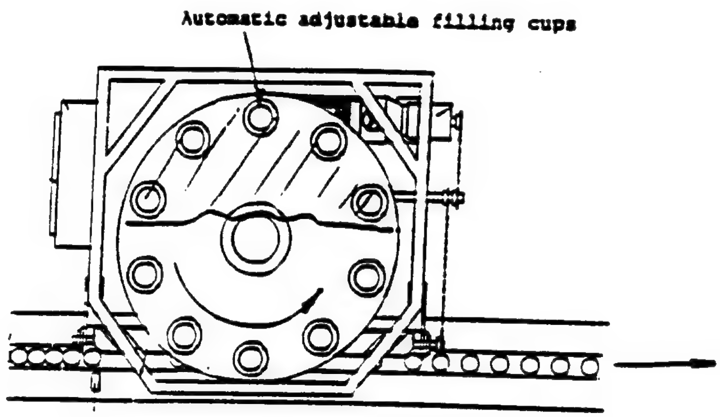
Personnel: T. Descovich and N. Litman

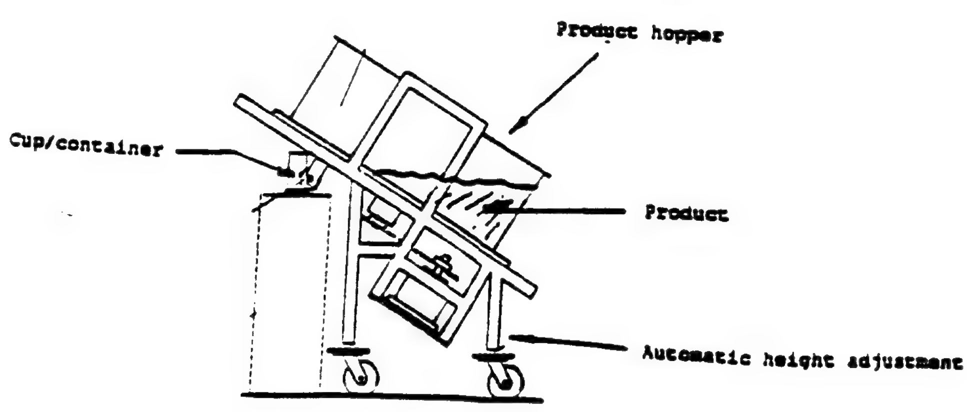
Characteristics/Advantages:

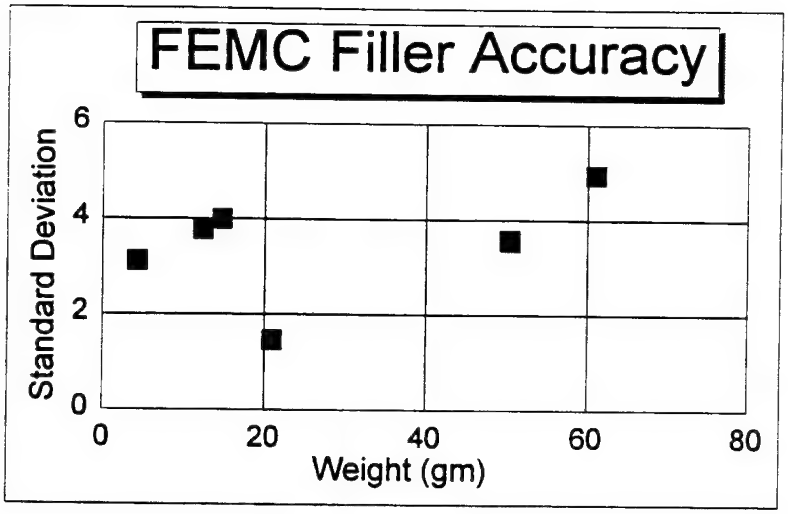
- Wide filling range
- Servomotor controlled adjustable filling cups
- Automatic filling machine height adjustment
- Dispenses delicate particulate products without damage
- Interchangeable portion filling cups
- Production rate up to 150 CPM

Status:

- Rotating buckets installed for Pouch line
- In operation






FEMC Filler Accuracy
Standard Deviation
0
2
4
6
0
20
40
60
80
Weight (gm)

Accuracy of the FEMC rotary filler after adjustments. 11/30/94

Thawed mi ed vegetabl es (grams)				Frozen vegetables
47.7		44.7		67.1
49.6		48.8		63.8
55.1		57.6		66.5
51		52		55.6
49		49.2		54.4
48.9		47.3		57.9
45.4		49.8		62.3
45.4		50.5		56.5
56.3		46.3		65.1
55.3		49.9		
46.2		53.3		
53.1		54.3		
51.9				
49				
52.2				
50.40667	**Avg**	50.30833	**Avg**	61.02222
2.940444	**AvgDev**	2.693056	**AvgDev**	4.375309
3.543498	**StdDev**	3.585947	**StdDev**	4.954487
7.03	**%Dev**	7.13	**%Dev**	8.12

Accuracy of the FEMC rotary filler after adjustments. 11/30/94

Thawed mixed vegetables (grams)				Frozen mixed vegetables		Thawed mixed vegetables with inserts
47.7		44.7		67.1		22.5
49.6		48.8		63.8		20
55.1		57.6		66.5		20.4
51		52		55.6		20.1
49		49.2		54.4		23.2
48.9		47.3		57.9		20.9
45.4		49.8		62.3		18.6
45.4		50.5		56.5		20
56.3		46.3		65.1		22.2
55.3		49.9				19.5
46.2		53.3				22
53.1		54.3				16.2
51.9						
49						
52.2						
50.40667	**Avg**	50.30833	**Avg**	61.02222	**Avg**	20.87778
2.940444	**AvgDev**	2.693056	**AvgDev**	4.375309	**AvgDev**	1.175309
3.543498	**StdDev**	3.585947	**StdDev**	4.954487	**StdDev**	1.472054
7.03	**%Dev**	7.13	**%Dev**	8.12	**%Dev**	7.05

Appendix 4.6
Meat Filling

SOLBERN

4.6.1

RFP# 1-6-27-3

The State University of New Jersey

RUTGERS

Cook College - Center for Advanced Food Technology

CRAMTD Program

Specifications

for

VOLUMETRIC FILLING MACHINE

This specification covers the requirements for a volumetric filling machine that will be used for the CRAMTD Program under STP #2 - Filling Systems for Combat Rations and Other Food Processes.

The machine will be used for the CRAMTD program demonstration site and for research and development of new packaging methods and materials.

This specification consists of the following sections.

1. Performance Requirements
2. Food Product Information
3. Package Information
4. Design Requirements
5. General
6. Acceptance
7. Shipping and Installation

1.0 Performance Requirements

1.1 Operational Duty. The equipment is to be capable of continuous operation in a typical food production environment. Minimum Operating Efficiency is 95%. This equipment must operate in a typical washdown area and must withstand the use of non-caustic detergent, bleach and high pressure water cleaning. Cleaning time will be provided daily as required by regulatory

agencies (i.e. FDA, USDA) or at least once per day.

1.2 Package Filling. The equipment will be filling pouches on an intermittent motion Horizontal Form-Fill-Seal Machine. As options, the equipment will fill Institutional sized pouches or half steam table trays on a continuous motion conveyor. The equipment will dispense the food product without bounce or splash onto the pouch seal area and will not drip between fill cycles. The food product is to be evenly distributed (not mounded) within the package.

1.3 Filling Rate. The equipment shall be capable of at least 20 fill cycles per minute. Each cycle will fill six small pouches or one Institutional size pouch per index. The fill cycle will be accomplished within 2.0 seconds of the "Start Fill" signal. The continuous motion conveyor line will be filled at a rate of 30 trays per minute.

1.4 Food Products. Filling equipment must meet Performance Requirements for food products specified in 2.0 Food Product Information.

1.5 Fill Volume. The equipment will fill from 0.5 ounce to 6 ounces per small pouch and from 8 ounces to 90 ounces per Institutional pouch. On the continuous motion line the equipment will fill from 8 ounces to 90 ounces per tray. The equipment will be capable of delivering the following accuracies, when thawed but not greater than 40 degrees F:

3.3 oz. Beef cubes (5/8") within +/- 5.0% by weight.
2.0 oz. Mixed vegetables (3/8") within +/- 3% by weight.
66 oz. Beef chunks (1"x1"x1.5") within +/- 3% by weight.

2.0 <u>Food Product Information</u>

2.1 Typical food products will be:

- Diced Vegetables 3/8" - dehydrated, frozen, freeze dried, chilled
- Carrot - pieces 2"x1"dia, sliced 3/8"x1"dia
- Potato - sliced 1/4"x2"dia, chunks 1.25"x.75"x.5"
- Cabbage strips 1"x2"
- Mixed vegetables
- Beans dry
- Peas, corn
- Apple slices
- Rice dry, blanched
- Berries
- Macaroni blanched 1"x.2"dia, spaghetti blanched 2", fettucini blanched 4"x1/4"
- Meat - 5/8" cube, 3/8" diced, 3/4"x3/4" chunk, 1"x1"x1.5" chunk, ground pre-cooked
- Meatballs - 5/8"-1" dia
- Bacon pieces

2.2 Fill temperatures from 0F to 180F.

2.3 Foods product may be frozen, thawed, dry, dehydrated, wet or greasy.

3.0 Package Information

Pouches and trays will be filled as per Drawing "A". Filling equipment should be capable of other pouch arrangements with minimal changes.

4.0 Design Requirements

4.1 Mechanical. Vendor to specify type of filling mechanism (i.e. volumetric cup, auger, vibrators, feeders, shuttle transfer, etc.) and all necessary equipment. Filling equipment is to include a feed hopper of 5 cubic feet or greater or appropriate feed system. If a traveling head is proposed for filling on the continuous motion conveyor, line speed synchronization will be compatible with buyer's Fenner M-Track controller. The equipment should have the capability of filling any combination of one to six pouches per index.

4.2 Pneumatic service up to 100 PSI. Vendor to specify pneumatic requirements.

4.3 Electrical. Voltage: 208V or 120V. Vendor to specify power requirements. All wiring, connections, control boxes, enclosures and components shall conform to NEMA 4 standards.

4.4 Controls. The equipment can be operated manually (single fill) or automatically. Automatic operation upon "Start Fill" signal from buyer's PLC. The filling equipment should be capable of returning a signal to the PLC at completion of fill. Equipment should be provided with visual alarm for low product level. Automatic operation on the continuous motion conveyor will be by tray sensor.

4.5 Construction. The equipment is to be mounted on castors and provide for easy alignment to the filling station as defined by Drawing "A". USDA requirements for food handling equipment apply. Exterior of equipment may be stainless steel, metal covered with USDA approved white epoxy paint and anodized or coated aluminum.

4.6 Physical dimensions, including location of utility hook-ups and weight of the equipment are to be provided.

4.7 Cleanability. Vendor will make every effort to facilitate cleaning, both internally and externally, and free from crevices.

4.8 Safety. Vendor will design filling equipment that is safe to operate. Applicable OSHA regulations must be observed.

4.9 Engineering Features. Settings for fill volume should be easily readjusted and reproducible. The vendor is encouraged to identify additional features which demonstrate equipment versatility.

5.0 General

5.1 Cost. The proposal is to include total cost be F.O.B. Rutgers University, Food Science Building, Cook College, New Brunswick, NJ. Cost of optional equipment, recommended spare parts and accessories should be quoted but clearly delineated from base bid.

5.2 Delivery Schedule. The vendor will specify engineering design, fabrication, testing and delivery schedule.

5.3 Service. The vendor will provide service as needed to fulfill requirements of the warranty and these specifications.

5.4 Drawings, Photos. A layout drawing of this machine shall be provided in both plan and elevation views. Photos shall be provided as needed.

5.5 Award. The criteria for selecting a proposal will be based on the evaluation of the CRAMTD staff:

Delivery
Performance
Engineering Features
Cost
Service
Training

5.6 Exceptions. The vendor is to clearly identify any exceptions taken from these specifications.

5.7 Warranty. The vendor warranties the equipment performance specified herein for one year from the date of acceptance.

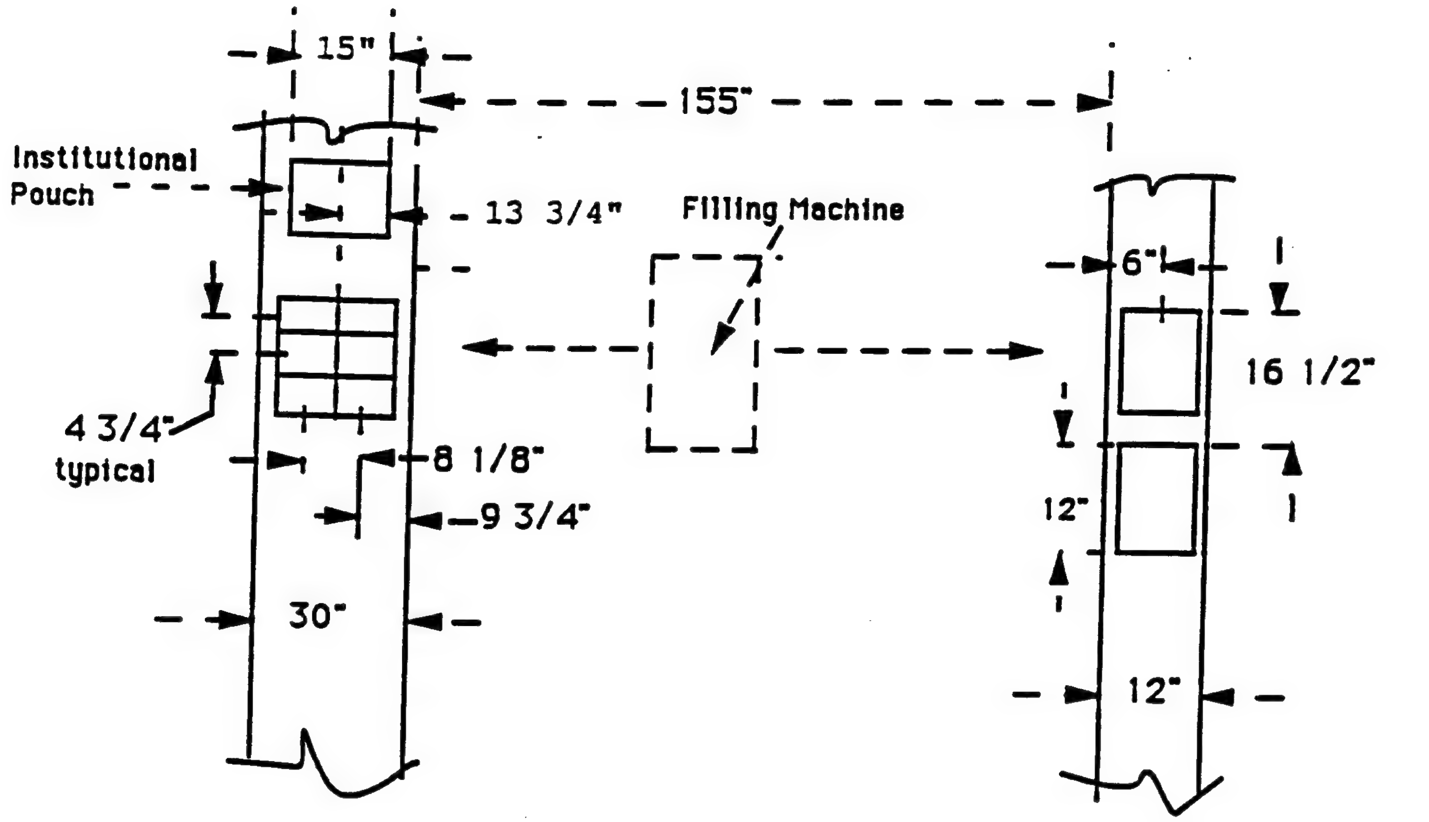
6.0 Acceptance

Acceptance Test. The equipment will be subject to an Acceptance Test to determine whether performance requirements have been met. The equipment will fill pouches for one hour at 17 cycles per minute. The equipment will fill trays on the continuous motion line for one hour at 20 trays per minute. Random samples will be taken and measured for accuracy of fill volume.

7.0 <u>Shipping and Installation</u>

7.1 The equipment will be shipped F.O.B., Rutgers University, Food Science Building, CAFT, Cook College, New Brunswick, NJ 08903.

7.2 The vendor will assemble and install equipment in full working order and provide training to Rutgers personnel in the operation and maintenance of the equipment.



HORIZONTAL FORM/FILL/SEAL MACHINE
INDEXING

Interior dimension of each pouch= 6 1/2"x3 1/8x7/8"
" " of institutional pouch= 12"x15"x2"
Height from floor = 36 1/2"

TRAY PACK LINE
CONTINUOUS MOTION

Interior dimension of tray=12"x10"x2"
Height of tray top from floor=48 1/2"

Ceiling height = 9'-0"

DRAWING "A"

3.4

Vendors for STP# 1 - Volumetric Filling Equipment

Spee-Dee Packaging Machinery, Inc.
P.O. Box 656
Sturtevant, WI 53177
Attn: David Navin
414 886-4402
cc: Roy Manas
316 South Woods Drive
Woodbury, NY 11797
516 957-1216

Per-Fil Industries
407 Adams Street
P.O. Box 9
Riverside, NJ 08075
Attn: Horst Boellmann
609 461-5700

Mateer Burt Co., Inc.
434 Devon Park Drive
Wayne, PA 19087
Attn: Kenneth Fissel
215 293-0100

HEMA U.S.A., Inc.
426 N.W. Universal Circle
Sandy, UT 84070
Attn: Steve Holbrook
801 565-1320

Solbern
8 Kulick Road
Fairfield, NJ 07004
Attn: Rick Shay
201 227-3030

Food Equipment Manufacturing Corporation FEMC
16900 Rockside Road
Maple Heights, OH 44137
Attn: Scott Burrows
216 663-1208

Raque Food Systems, Inc.
P.O. Box 99416
11002 Decimal Drive
Louisville, KY 40299
Attn: Jack Hayden
502 267-9641

1. RETURN SIGNED QUOTATION IN A SEALED ENVELOPE. SHOW RFQ # ON OUTSIDE OF ENVELOPE.
2. IN EVENT OF THIS BID BEING ACCEPTED, A PURCHASE ORDER WILL BE SENT.
3. SEE REVERSE SIDE FOR TERMS & CONDITIONS.
4. ANY EXPENSE INCURRED BY THE BIDDER IN CONNECTION WITH THIS QUOTATION IS THE SOLE RESPONSIBILITY OF THE BI
5. IF QUOTE IS NOT F.O.B. DESTINATION, YOU MUST SHOW COST OF FREIGHT AS A SEPARATE ITEM.

ATTN RICK SHAY
SOLBERN
F VILLICY RD
FAIRFIELD NJ 07004

4.6.2

DATE	THIS BID WILL BE OPENED:		
6/27/91	SEALED PROPOSAL DUE JULY 24, 1991	TIME 2:30 PM	BY GEORGE THO... R DIRECTOR OF PURCHASES
	PLEASE QUOTE THE FOLLOWING F.O.B. DESTINATION		

RUTGER, THE STATE UNIVERSITY OF NJ, requests proposals for the Design, Manufacturer, and Installation of a Volumetric Filling System in accordance with the attached Specifications and following notes.

NOTES:

A. MANDATORY PRE-BID CONFERENCE

IT IS MANDATORY THAT ALL PROSPECTIVE VENDORS ATTEND THIS PRE-BID CONFERENCE IN ORDER TO CLARIFY ANY SPECIFICATIONS/DETAILS AND ACQUAINT THEMSELVES WITH THE PROPOSAL TO BE SUBMITTED. EACH VENDOR MUST SIGN THE REGISTER TO VERIFY HIS/HER ATTENDANCE. FAILURE TO ATTEND THIS PREBID CONFERENCE WILL RESULT IN DISQUALIFICATION OF YOUR PROPOSAL.

The Pre-Bid Conference will be held:

DATE: July 10, 1991
TIME: 1:30 PM
LOCATION: Rutgers University Food Science Bldg, CAFT, corner of College Farm and Dudley Rds, Conference Rm #120A, New Brunswick, NJ 08903

B. Technical questions pertaining to specifications are directed to Mr. Theordore Descov at 908-932-8307. Questions pertaining to proposal procedures are directed to Mr. Michae Dunn at 908-932-5070.

C. The following areas must be addressed in detail with each proposal and will be considered in the evaluation: Delivery, performance, engineering features, cost service and training.

D. Prices are to be F.O.B. Rutgers University Food Science Building, CAFT, Cook College, New Brunswick, NJ, freight included.

E. All of optional equipment, recommended spare parts and accessories shall be priced individually and included on a separate sheet within your proposal.

PLEASE INDICATE COST OF PROPOSAL AS FOLLOWS:

LUMP SUM $209,680.00

Delivery & Installation 126 Days ARO

1. Please note additional Terms & Conditions on reverse side of this sheet.
2. It is the bidders responsibility to see that their proposal arrives at the University Procurement & Contracting Office before the proposal opening date and time.
3. Proposals delivered in person or by express service should be to our actual location. This location is: RUTGERS -THE STATE UNIVERSITY of New Jersey
University Procurement & Contracting
Administrative Services Annex Building/Room 101,
Davidson Road/Busch Campus
PO Box 6999
Piscataway, NJ 08855-6999

REFER ALL QUESTIONS REGARDING THIS REQUEST TO:	NOTE: SHOW ALL TAXES AS SEPARATE ITEM	GRAND TOTAL →	
MICHAEL DUNN/lg/(908)932-5070			209,680.0(

THIS SPACE TO BE FILLED IN BY BIDDER

SHIPMENT CAN BE MADE IN 126 DAYS FROM RECEIPT OF ORDER	We quote you as above subject to the Terms and Conditions on the reverse.	
F.O.B. Delivered	SIGNATURE: Claude Tribert	
TERMS: 20% Deposit with order, Balance Net 30 days date of invoice.	PRINT NAME AND TITLE Claude Tribert, President	PHONE NUMBER (201)227-3030

5-002 Rev

SOLBERN

Mr. Michael H. Dunn
Senior Buyer
RUTGERS STATE UNIVERSITY OF NEW JERSEY
University Procurement & Contracting
Administrative Services Annex Building/Room 101
Davidson Road/Busch Campus
P.O. Box 6999
Piscataway, NJ 08855-6999

August 6, 1991

* *

2. ONE SOLBERN CUP DUMPER ASSEMBLY FOR POUCH FILLING, with:

(a) Capacity to fill 6 pouches simultaneously. 17 cycles per minute.
(b) Programmable controller operated (located on filling machine).
(c) Pneumatically operated transfer motions.
(d) Stainless steel construction or F.D.A. approved construction.
(e) One set of machine safety guards.
(f) One set of product handling cups (quantity 160) 5.3 oz. size.

* *

3. ONE SOLBERN CUP DUMPER ASSEMBLY FOR TRAY FILLING, with:

(a) Capacity to fill 15 trays/min. - adjustable.
(b) Programmable controller operated (located on filling machine).
(c) Pneumatically operated transfer motions.
(d) Stainless steel construction or F.D.A. approved construction.
(e) One set of machine safety guards.
(f) One set of product handling cups (quantity 50) 33 oz. size.

TOTAL SYSTEM PRICE: $209,680.00

OPTIONAL:

(a) ELECTRIC LINEAR ACTUATOR (OPTIONAL): To replace the long stroke air cylinder for transferring the (2) inverted cups for tray filling. The electric linear actuator will be a Nema 4 housed ball screw assembly, capable of variable speed operation from 0" to 6" per second, complete with a Nema 4 drive controller.

$6,505.00

(b) VIBRATORY PRODUCT INFEED CONVEYOR (OPTIONAL): Per attached standard description with 2 cu. ft. supply hopper.

$5,742.00

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Piscataway, NJ 08855-6999

August 6, 1991

* *

SHIP ON OR ABOUT: 16-18 weeks after receipt of order and deposit.

TERMS: 20% deposit with order, balance net 30 days date of invoice.

NOTE: This quotation is valid for a period of 45 days as per Form T-12 attached. Prices must be reconfirmed, in writing, after that period.

T-12
PG:bjd

SOLBERN

EXCEPTIONS TO
SPECIFICATIONS FOR VOLUMETRIC FILLING MACHINE
RUTGERS RFP #1-6-27-3

PAR 1.2 PACKAGE FILLING.

Product distribution will be maximized but customer must employ manual methods to achieve an even product distribution.

PAR 1.3 FILLING RATE.

The continuous motion cup dumping system will be designed to cycle at a rate of up to 30 trays per minute but the system performance may be less than satisfactory at speeds above 15 trays per minute.

PAR 1.4 FOOD PRODUCTS.

The proposed filling system is capable of handling a wide variety of vegetable, meat and fruit products. The system quoted has product handling cups sized to fill those products defined in Par 1.5.

PAR 1.5 FILL VOLUME.

The proposed filling system employs a set of product handling cups sized to deliver the desired volume and allows that volume to be adjusted by approximately ± 10%. One set of 5.3 oz. product handling cups (quantity 160) is provided for filling of the (6) pouches simultaneously. Also, one set of 33 oz. product handling cups (quantity 50) is provided for tray filling. In filling applications where multiple products must be filled, the customer may elect to prefill the product handling cup before it enters the Solbern Filling Machine. The Solbern Filler would then add the product which fills the remainder of the cup. Any auxiliary product feeling devices must be supplied by the customer.

The filling accuracy of the proposed system is dependent on many variables such as product uniformity, product size, volumetric cup configuration, filling machine adjustments and container line speed. The filling machine proposed for the system is widely used in many commercial canning operations on a wide variety of products. Every effort will be made to achieve the desired fill accuracy but such accuracies cannot be guaranteed.

SOLBERN

PAR 3.0 PACKAGE INFORMATION.

Filling of the institutional pouch will be accomplished by utilizing the cup dumping mechanism designed for the tray packing. The basic design of the filling system allows the cup dumping system to be custom-designed to accommodate different fill patters. To fill other pouch arrangements it will be necessary that the cup dumper be replaced with one having the desired pattern.

PAR 4.1 DESIGN REQUIREMENTS.

The filling machine is equipped with a product level control which regulates the quantity of product within the filling drum. The product "low level" sensor will be wired to a visual alarm and product may be added manually from a tote box.

If desired, a Vibratory Product Infeed Conveyor having a two (2) cubic foot capacity hopper is offered as an optional extra.

The cup dumping system on the continuous motion line is offered with an optional Variable Speed Electric Linear Actuator in place of a pneumatic cylinder. The activator speed must be manually preset to match the tray speed.

As defined in the exception for Par 3.0, the equipment proposed is for use with one or six pouches. Other pouch configurations require replacing the cup dumper.

PAR 5.7 WARRENTY.

Revise one year period to six months.

PAR 6.0 ACCEPTANCE.

Revise speed of test on continuous motion line to 15 trays per minute and delete fill accuracy testing.

SOLBERN

Division of Howden Food Equipment Inc.

8 Kulick Road, Fairfield, NJ 07004-3385

(201) 227-3030 Fax (201) 227-3069

CUP DUMPER - BASIC SYSTEM DESCRIPTION

GENERAL DESCRIPTION

The Cup Dumper System is a transfer type filling method which delivers pre-measured portions to a single container or simultaneously to multiple containers (i.e. trays, pouches, jars, etc.). The system concept is highly flexible which permits it to be designed for specific multiple filling patterns.

A system consists of a Filling Machine for the filling of product handling cups, a quantity of product handling cups, and a Cup Dumper Assembly. The functions of each are as follows:

1. Filling Machine

   The Filling Machine utilizes the product handling cup as a measuring device for precise filling. The shake-while-progressively-filling feature orients the product within the cup to achieve uniform fill density. A combination of adjustable cup volume and fill angle of the cup determines the fill volume.

   The product handling cups are conveyed through the Filling Machine upon a horizontal type closed loop belt conveyor. At the discharge end of the feed side of the conveyor belt, the filled product handling cups are supplied to the Cup Dumper Assembly.

   Cups processed by the Cup Dumper Assembly are returned to the Filling Machine conveyor belt on the return side so they may re-enter the Filler. There are several proven models of Filling Machines which may be used depending on the specific application.

2. Cup Dumper Assembly

   The Cup Dumper Assembly is a separate unit designed specifically for the desired filling pattern. This unit is a free-standing assembly which is positioned adjacent to and over the containers to be filled.

   The assembly consists of a horizontal closed loop conveyor belt to convey the product handling cups, cup inverting mechanism and cup gating devices.

SOLBERN

The conveyor belt receives filled product handling cups from the Filling Machine and maintains a supply of cups for the system. This conveyor also handles the processed cups for return to the Filling Machine.

The Cup Inverting Mechanism controls transfer of the product from the product handling cup into the container below. The mechanism is generally sized to accommodate two product handling cups, one following the other. When a cup is transferred into the inverting mechanism, it is in its normal upright position (open end up). The first position of the Inverting Mechanism has a closed top and bottom which essentially seals off both the top and bottom of the product handling cup. When a cup is transferred into the first position, a time delay is initiated. At the end of the time delay, the Inverting Mechanism rotates 180°. The cup which was just introduced is now inverted and the product within the cup is retained by the closed sections of the mechanism. When the next cup is transferred into the Inverting Mechanism, it "pushes" the inverted cup into the second position within the mechanism. The second cup position of the mechanism has its top and bottom areas open so the product is dropped as the cup moves into this position. The time delay prior to the inverting motion is to allow sufficient time for all of the product to drop into the container. As each filled cup is transferred into the Inverting Mechanism, a cup is pushed out and is in its normal upright position (open end up().

For applications which utilize an intermittent motion cycle (index-dwell systems) to transport containers to be filled, a signal is given at the start of the dwell portion of the cycle. Upon receiving this signal, the product handling cups are transferred into the inverting mechanisms and product is dropped from the cups within. The Cup Dumper Assembly then continues to complete its cycle, inverting and preparing the next group of cups for transfer.

For applications which utilize a continuous motion of the containers to be filled it is necessary that the containers have a space between them during filling. This space must allow adequate time for the inverting motion of the product handling cup. When the container is properly positioned to receive product, a signal is given to the Cup Dumper Assembly. Upon receiving this signal, the product handling cup is transferred into the Inverting Mechanism at a speed equal to the containers aligned below. As both are travelling at the same rate of speed and are aligned to each other, the product is transferred from the inverted product handling cup into the container.

SOLBERN

The Cup Dumper Assembly may also operate on a no-container no-fill (or defective pouch-no-fill) basis if the dispense signal to the Dumper is not given.

3. Product Handling Cups

The product handling cups have an outside diameter which is sized to accommodate a specific filling pattern. This is necessary since the cups are transferred into the inverting mechanisms from a single line supply and the handling patterns may require transferring every other cup, or every third cup, etc.

The cup design incorporates an adjustable bottom which may be adjusted in increments to change the internal volume of the cup. The quantity of cups required depends upon the specific filling pattern and fill rate required.

Generally, the Cup Dumper Assembly operates at a line speed greater than that on the Filling Machine. This requires that the return side of the Filling Machine conveyor belt be completely filled with cups to prevent gaps in the line of cups during filling.

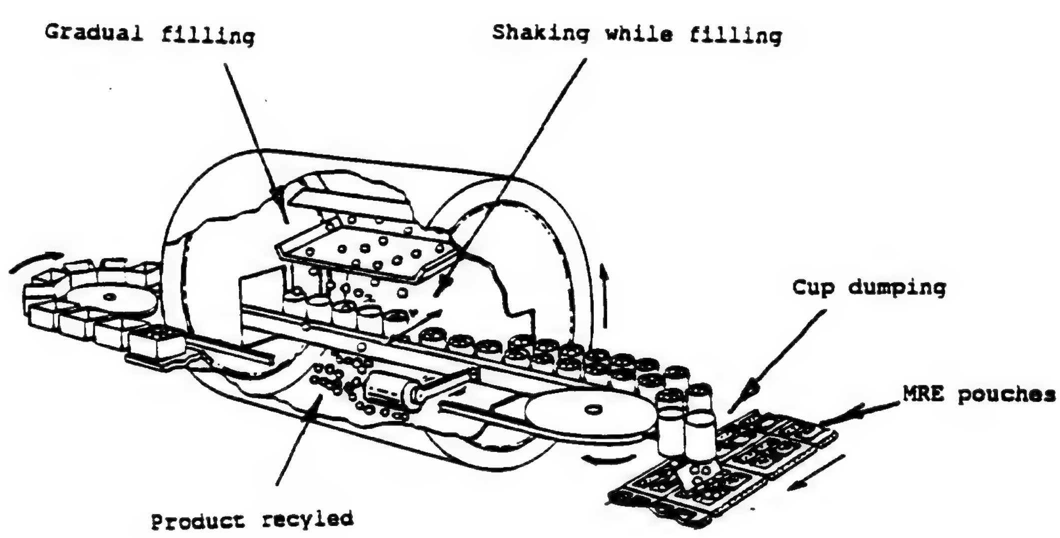
Combat Ration Advanced Manufacturing Technology Demonstration (CRAMTD)

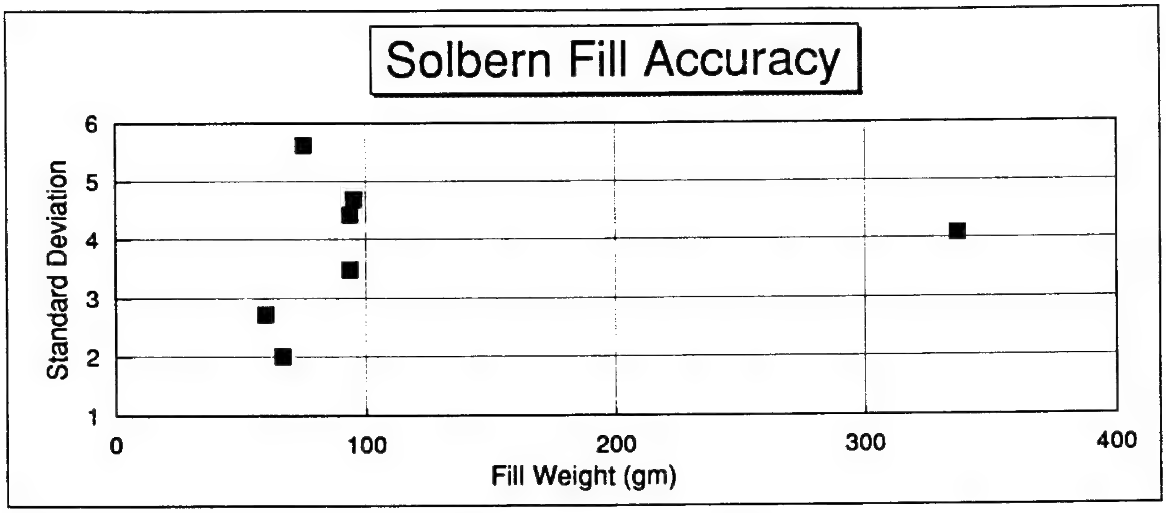
Operation: Automated Filling Systems

Equipment: Volumetric Filling of Solids (Transfer Filler)(Solbern)

Characteristics/Advantages:

- Handles a wide filling range
- Fills product into cups that shake during filling for a more accurate fill
- Cup design has a movable bottom plate that may be adjusted to change the fill volume
- Checkweigher can be added for more accurate filling
- Can fill directly into variety of containers
- Production rate up to 600 CPM
- Adjustable filling machine height
- Accomodates full range of products, wet or dry





Solbern Fill Accuracy
Standard Deviation
6
5
4
3
2
1
0
100
200
300
400
Fill Weight (gm)

4.6.4

Report on fill accuracy of the Solbern Volumetric Filler **5/5/94**

Objective-To determine the fill weight accuracy of mixed vegetables and diced beef cubes for beef stew on the Solbern tumble filler.

Procedure-In the case of diced beef (5/8" cube from Herman Alpert), cup depth was positioned at approximately 1-1/4" to deliver 92.4g (target weight for CRAMTD Beef Stew in MRE pouches). The machine was run according to outlined procedure located at the machine, cups were pulled off the line, dumped, and the meat was weighed. In the case of vegetables (Potatoes and Carrots), cups were filled, then conveyed to the Tiromat horizontal Form/Fill/Seal machine for transfer into pouches. 2 sets of (20) sealed pouches each were selected for weighing. The vegetables were left intact in the pouches and 1 empty pouch was weighed to tare the results.The meat cups were weighed immediately after the filler.

Conditions-The specifications for the beef and mixed vegetables are to be thawed but not above 40 degrees Fahrenheit. Both were thawed for this experiment.

Results-Weight accuracy measurements are tabulated in figure 1. Experiments were performed with both mixed vegetables and diced beef cubes though the Solbern will primarily be used for the meat. For the diced beef, an average weight of 93.4g was attained compared to a target weight of 92.4g. The range of values was also comparable to the specification of +/-5.0%. The accuracy is expected to improve during production since the data is based on a relatively small sample size.

4.6.4

Figure 1

Weight data of Solbern Volumetric Filler (grams) on 4/5/94

Mixed vegetables	Diced meat
59.99	92
61.24	90.4
61.19	90.5
67.39	99.1
63.88	88.1
58.28	94
62.22	95.8
61.63	94.5
61.35	94.2
59.05	87.6
66.33	88.6
64.61	93
63.74	91.9
60.9	96.5
59.95	88
62.99	93.4
64.71	103.8
55.78	88.4
53.12	95.6
67.88	101.9
58.44	89.3
52.66	97.3
58.49	95.3
59.52	
60.16	93.44 **Avg(gm)**
55.7	3.49 **AvgDev(gm)**
59.94	4.43 **StdDev(gm)**
60.02	4.74 **%Dev**
57.8	
57.45	
58.37	
57.27	
55.39	
58.76	
56.12	
59.43	
58.77	
56.51	
58.3	
55.45	
59.77 **Avg(gm)**	
2.72 **AvgDev(gm)**	
3.55 **StdDev(gm)**	
5.94 **%Dev**	

Product was filled at between 32 and 40 degrees Fahrenheit.
Cup depth was positioned at approximately 1-1/4".

Following are the data collected during the ACB demo run, March 8, 1995

1. Beef net weight: Beef samples were collected after the checkweigher (Solbern).

2. Beef and vegetable net weight: Pouches filled with beef and vegetables were collected at the end of the Tiromat.

	Beef Net Weight / g	Beef and Veget Net Wt / g
	70.91	118.88
	81.76	106.39
	65.85	122.36
	79.49	106.71
	76.66	108.61
	71.97	127.95
	74.67	116.06
	75.41	124.91
	82.72	118.71
	76.55	126.03
	65.98	145.07
	84.91	124.18
	71.92	132.64
	75.32	128.93
	71.26	122.47
Average	75.03	121.99
Std Dev.	5.63	10.25
Maximum	84.91	145.07
Minimum	65.85	106.39
Range	19.06	38.68
No. sample:	15	15

Appendix 4.7
Placeable Filling

6/26/92 4.7.1

RFP# 2-6-25-2

The State University of New Jersey

RUTGERS

Cook College - Center for Advanced Food Technology

CRAMTD Program

Specifications

for

ROBOTIC FILLING SYSTEM INTEGRATION

This specification covers the requirements for a robotic food handling work cell that will be used for the CRAMTD Program under STP #2 - Filling Systems for Combat Rations and Other Food Processes. This specification does not include the robot unit which will be provided by Rutgers.

The system will be used for the CRAMTD program demonstration site and for research and development of new packaging methods and materials.

This specification consists of the following sections.

1. Performance Requirements
2. Food Product Information
3. Package Information
4. Design Requirements
5. General
6. Acceptance
7. Shipping and Installation

1.0 Performance Requirements

1.1 Operational Duty. The system is to be capable of continuous operation in a typical food production environment with a Minimum Operating Efficiency of 98%. Minimum Operating Efficiency is defined as percentage of time which equipment performs at specified rate and accuracy. This equipment must operate in a typical washdown area and must withstand the use of non-caustic detergent, bleach and high pressure water cleaning. Cleaning time will be provided daily as required by regulatory agencies (i.e. FDA, USDA) or at least once per day.

1.2 Container Filling. The robot will place product into pouches on a Tiromat horizontal form-fill-seal machine. Product will be placed on the robot infeed conveyor manually at random.

1.3 Production Rate. The system shall be targeted for filling 102 pouches per minute and capable of filling at least 60 pouches per minute.

1.4 Food Products. Filling equipment must meet Performance Requirements for food products specified in 2.0 Food Product Information. The filler is to handle food products without damage. Gripping devices shall not drop product.

2.0 Food Product Information

2.1 The system must be capabable of filling thawed or frozen Ham Slice 3" x 4" x 5/8" (approximately 3.5 ounces).

3.0 Pouch Information

3.1 The equipment will fill 6 pouches per index on a horizontal form-fill-seal machine (See Figure 1 for pouch arrangement). The pouch web is approximately 36" above the floor.

3.2 As an option, the equipment will assemble several packeted components into pouches configured 2 per index.

4.0 Design Requirements

4.1 Equipment Provided. The following equipment will be shipped to the vendor's manufacturing site for system integration:

- Adept PackOne Robot with HyperDrive
- A-Series MC Controller with 4 Mb system processor
- Color Monitor, Programmers Keyboard, Mouse
- Manual Control Pendant
- Adept Vision AGS-GV with 4 Mb system coprocessor
- Medium Resolution Camera
- AIM MotionWare and Vision Module

The equipment provided as Attachment A.

4.1 Integration Equipment. Vendor will provide the folowing items:

- Robot subbase
- Software (application programming)
- Vision Camera Lens and Lighting (if needed)
- Product Grippers/End Effector
- Product Infeed Conveyor
- Safety Guarding

The vendor is to define hardware, software and all necessary equipment in the bid proposal. Gripper devices are to be interchangable.

4.2 Pneumatic service up to 100 PSI. Vendor to specify pneumatic requirements. Vacuum service available.

4.4 Controls. The equipment will operate automatically when given a "start fill" signal from a horizontal form-fill-seal machine and return a "finished fill" signal at the completion of the fill cycle.

4.5 Construction. The robot system must meet USDA requirements for food handling equipment. The controller will located outside the washdown area.

4.6 Physical dimensions, including location of utility hook-ups and weight of the equipment are to be provided.

4.7 Cleanability. Vendor will design equipment for easy cleaning.

4.8 Safety. Vendor will design filling equipment that is safe to operate. Safety guards are to be provided where required.

5.0 General

5.1 Cost. The proposal is to include total cost F.O.B. Rutgers University, Food Science Building, Cook College, New Brunswick, NJ. Cost of optional equipment, recommended spare parts and accessories should be quoted but clearly delineated from base bid.

5.2 Delivery Schedule. The vendor will specify engineering design, fabrication, testing and delivery schedule.

5.3 Service. The vendor will provide service as needed to fulfill requirements of the warranty and these specifications.

5.4 Manuals. Equipment operational procedure and maintenance will be fully documented in a set of manuals.

5.5 Drawings, Photos. A layout drawing of this machine shall be provided in both plan and elevation views. Photos shall be provided as needed.

5.6 Award. The criteria for selecting a proposal will be based on the evaluation of the CRAMTD staff:

Delivery
Performance
Engineering Features
Cost
Service
Training

5.7 Exceptions. The vendor is to clearly identify any exceptions taken from these specifications.

5.8 Warranty. The vendor warrants the equipment performance specified herein for one year from the date of acceptance. The warranty includes all equipment and software supplied to be free from defects in materials and workmanship.

6.0 Acceptance

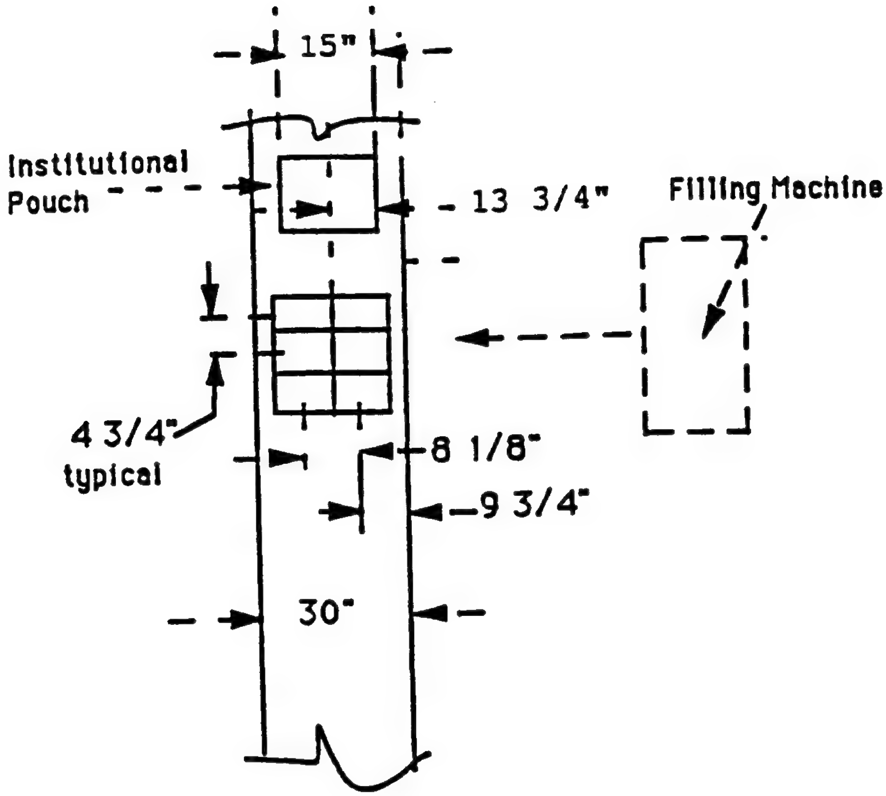
6.1 Acceptance Test. The equipment will be subject to an Acceptance Test at Rutgers to determine whether performance requirements have been met. The equipment will fill pouches for one hour at the target rate of 102 pouches per minute but not less than 60 pouches per minute.

7.0 Shipping and Installation

7.1 The equipment will be shipped F.O.B., Rutgers University, Food Science Building, CAFT, Cook College, New Brunswick, NJ 08903.

6/26/92

7.2 The vendor will assemble and install equipment in full working order and provide training to Rutgers personnel in the operation and maintenance of the equipment.



HORIZONTAL FORM/FILL/SEAL MACHINE
INDEXING

Interior dimension of each pouch= 6 1/2"x3 1/8x7/8"
" " of institutional pouch= 12"x15"x2"

Height from floor = 36 1/2"

Ceiling height = 9'-0"

DRAWING "A"

4.7.2

adept technology, inc.

150 Rose Orchard Way San Jose, CA 95134
(408) 432-0888 FAX (408) 432-8707

QUOTATION NO.: C3959EB-2

SHIPMENT SCHEDULE: 18 to 22 weeks after receipt of hard copy purchase order subject to prior sale

QUOTATION DATE: May 15, 1992

SHIPMENT TERMS: FOB San Jose, CA

VALID UNTIL: June 15, 1992

TERMS OF PAYMENT: ***Net 30 days Subject to Credit Approval.***
(The attached Terms of Sale Bulletin also forms a part of this Quotation)

CUSTOMER: Mr. Ted Descovich
Rutgers University
P.O. Box 231
New Brunswick, NJ 08903

EQUIPMENT PACKED FOR: Air ride van

FOR FURTHER COMMUNICATION ON THIS QUOTATION, CONTACT:

Primary: Ernie Bancroft (215)322-5221
Secondary: Sherry Dalton (513)792-0266

ITEM	DESCRIPTION	P/N	UNIT PRICE	QTY	TOTAL PRICE
1	Adept PackOne Robot 4-axis SCARA robot Including: - 7.7" (196 mm) vertical stroke - Standard tool flange - Protective seals and covers - Internal air circulation system - PackOne surface treatment - Accessory kit - Manual set	90844-00010	$38,800 Less 35% discount	1	$38,800 $13,580 $25,220
2	Adept A-Series MC Controller 208/220/240 VAC, 50-60 Hz, NEMA 1 robot controller with single phase power supply Including: -V+ language and operating system -20 Mb hard disk drive -Two 3.5" floppy disk drives -Internal 32-channel digital I/O board -Four RS-232C serial ports -GFX system processor with 16.7 MHz 68000, separate graphics processor, 2 Mb of system memory, and 2 Mb of graphics memory -Power/door interlock with mechanical contactor -Accessory Kit -User's manual	90310-01020	$26,400 Less 35% discount	1	$26,400 $9,240 $17,160

ITEM	DESCRIPTION	P/N	UNIT PRICE	QTY	TOTAL PRICE
3	A-Series Monitor High-resolution (800 x 600) color monitor for all A-Series controllers with 100-240 VAC, 50/60 Hz universal power supply and monitor-to-controller adapter cable	10154-10230	$1,150 Less 30% discount	1	$1,150 $345 $805
4	A-Series Programmer's Keyboard 101-key keyboard for Adept MC, CC, and IC A-Series Controllers Including: -V+ compatible keyboard -Keyboard-to-serial port adapter cable -Function key label	10154-10220	$250 Less 30% discount	1	$250 $75 $175
5	A-Series Mechanical Serial Mouse Mechanical mouse for Adept MC, CC and IC A-Series controllers Including: -V+ compatible mouse -Mouse-to-serial port adapter cable	10154-10320	$190 Less 30% discount	1	$190 $57 $133
6	Manual control pendant	90310-48000	$1,600 Less 30% discount	1	$1,600 $480 $1,120
			Total this Quotation		$44,613

ITEM	DESCRIPTION	P/N	UNIT PRICE	QTY	TOTAL PRICE
	AVAILABLE AS OPTIONS:				
7	Adept HyperDrive for the PackOne robot. Performance enhancement package including high-output amplifiers, adaptive servo code, optimal-speed trajectory planning software, and dedicated 68020 auxiliary servo processor This option does conform to USDA approvals.	90846-00200	$4,500 Less 30% discount	1	$4,500 $1,350 $3,150
8	AdeptVision AGS-GV for the Adept MC controller Integrated vision for inspection and guidance of Adept robots. Requires A-Series controller and V+ 10.0 or later. Including: - 2 Mb 33 MHz 68020 vision processor - Dual SFG frame grabber - Camera multiplexer (supports 8 cameras and 4 strobe channels) - 512 H x 484 V system resolution - Advanced camera calibration software - User's manual	90154-00300	$19,500 Less 65% discount	1	$19,500 $12,675 $6,825
9	Medium resolution camera, 501 horizontal by 485 vertical pixels, with cable. Lenses must be purchased separately. AGS System resolution is 512 x 484.	10152-15002	$1,300 Less 30% discount	1	$1,300 $390 $910
10	AIM MotionWare Assembly and Information Manager software for robotic assembly and material handling applications. Version 2.x Requires A-Series controller. Includes: - AIM Baseline System - AIM Robot Module - Manual set	90712-0x600	$3,000	1	$100 Special University pricing
11	AIM Vision Module Assembly and Information Manager vision support software and documentation. Version 2.x. Requires AdeptVision AGS-GV and the 4Mb system processor option.	90712-0x205	$2,000	1	$100 Special University pricing

ITEM	DESCRIPTION	P/N	UNIT PRICE	QTY	TOTAL PRICE
12	4 Mb 33 MHz 68020 system co-processor	90310-00400	$3,700	1	$3,700
			Less 30% discount		$1,110
					$2,590
13	4Mb A-Series System Processor 4Mb processor to replace standard 2Mb processor on A-Series controllers. Must be specified when ordering controller.	10154-66200	$500	1	$500
			Less 30% discount		$150
					$350

Prepared by: Sherry Patton

Authorized by: [signature]

Address order to:
ADEPT TECHNOLOGY, INC.
ATTN: Sales Operations
150 Rose Orchard Way
San Jose, CA 95134

NOTE: Please refer to the above quotation number on any correspondence related to this quotation.

EWINGGEAR™
Services, Inc.

4.7.2

HAM SLICE

TRANSFER SYSTEM

QUOTATION 92H01

- FOR -

RUTGERS UNIVERSITY/CRAMTD

RFP # 2-6-25-2

NEW BRUNSWICK, NJ

10 AUGUST 1992

EwingGear™ Services, Inc.
Route 9, RD# 5, Box 203
Valatie, NY 12184
518/732-[illegible]

Robert E. Price, CMfgE
General Manager

EWINGGEAR™
Services, Inc.

RUTGERS/CRAMTD
RFP #2-6-25-2

Proposal 92H01
Ham Slice Trnsfr. Sys.

10 Aug 1992

1.0 GENERAL

1.1 This proposal is in response to Rutgers/CRAMTD RFP #2-6-25-2 dated 25 June 92 and subsequent amendments #1 and #2, dated 24 July and 3 August. Our understanding is that Rutgers/CRAMTD wishes to purchase an automated system to acquire and transfer ham slices from a moving conveyor belt to an array of recesses formed in a sheet plastic food container.

1.2 This equipment is to be designed to meet all applicable USDA regulations regarding food handling equipment. Those regulations require that all of the equipment be capable of being cleaned using water containing various cleaning agents on a daily basis. This procedure is commonly referred to as "washdown capability."

1.3 Specifically, the operating conditions are as follows:

1.3.1 Ham slices, approximately 3" X 4" X 5/8" thick, weighing approximately 3½ ozs., will be placed randomly on a conveyor belt. The slices will be placed on the conveyor so as to require a maximum transfer rate of 102 slices of ham per minute with a minimum acceptable rate of 60 slices per minute. The ham slices must be manually placed so that they do not overlap. The ham slices must be one piece with no loose pieces.

1.3.2 The forming machine produces six pockets in the film for each machine cycle. Pockets are formed in a 3 X 2 array from a film web approximately 20" wide. The robotic transfer equipment must place each slice in the center of each of the six pockets. The array of pockets will be stationary during the placement of the slices.

1.3.3 Robotic transfer equipment will be used to automatically acquire a ham slice or slices, orient the slice and transfer it into the pockets.

1.3.4 The robotic equipment is to be furnished complete with an integrated machine vision system which must, in real time, view the ham slices as they move along the conveyor, determine their orientation and their centroid, orient a suitably

mine their orientation and their centroid, orient a suitably configured gripper to acquire one or more of the ham slices so as to meet the required transfer rates, control the conveyor and communicate with the package forming machine.

1.3.5 The equipment is to be furnished with a suitable conveyor system complete with its local controls and drives. All of the equipment furnished is to be controlled by the robot's primary controller using Adept's V+ software.

1.4 It is our understanding that Rutgers University has purchased an Adept Technology, Inc. model PackOne® robot equipped with its control system and machine vision software and hardware. The system integrator must furnish a suitable lens for the camera to be furnished by Rutgers/CRAMDT and a food grade enclosure for the camera/lens assembly.

2.0 SYSTEM DESCRIPTION

2.1 EwingGear™ Services proposes to furnish all of the necessary engineering, design, programming, assembly and test services to completely integrate the Rutgers/Adept robot, as well as furnish a special gripper, a conveyor system and other related equipment necessary to carry out the previously defined automated material handling tasks.

2.2 The conveyor system will be a food grade rated machine constructed using 304 stainless steel for the frame with an eight inch wide food grade white belt. Overall conveyor length will be approximately eight feet. The conveyor system will be mounted on a stainless steel weldment to position it at an appropriate height above the floor.

2.3 The conveyor will be driven by a TEFC motor/gear drive mounted below the conveyor and controlled by a solid state adjustable speed drive. The conveyor will pass over the existing Rutgers container forming conveyor so that product which is not acquired by the robot can be allowed to drop into a stainless steel receptacle positioned on the floor alongside the existing conveyor. Conveyor controls and drives will be mounted in a stainless steel NEMA 4 enclosure. All conveyor hardware will be 300 series stainless steel.

2.3.1 In order to provide ham slice position information to the robot controller and machine vision system, the conveyor drive must be fitted with an encoder. The encoder is available as a standard Adept Technology part designed to readily interface to the Adept controller and software. Since Rutgers/CRAMDT did not order the encoder, EwingGear™ Services is prepared to supply one and has included it as an optional item. Note that the Adept encoder does not meet USDA requirements. The price quoted includes a suitable enclosure and cable set.

2.4 The Adept PackOne® robot will be mounted on a 304 stainless steel weldment to suitably position it above the ham slice conveyor. The stand will robustly anchor the robot to the floor so as to withstand the forces generated by the high-speed motions of the robot. The stand will be furnished complete with properly sized stainless steel anchor bolts and related hardware.

2.5 Attached to the wrist flange of the fourth axis of the Adept robot will be a EwingGear™ Services specially engineered gripper designed to quickly and reliably acquire the ham slices. The gripper will be fabricated from stainless steel and a food grade polymer such as acetal or glass-reinforced nylon.

2.5.1 The ham slices will be acquired by inserting an array of stainless steel needles into the ham and then shifting half of the needles outward so as to slightly stretch the ham slice to assure positive gripping of the resilient ham material.

2.5.2 Ham slices will be released from the gripper with a pneumatically actuated stripper mechanism which will move down over the needles and positively mechanically displace the ham slice.

2.5.3 The pneumatically controlled gripper will be equipped with a series of non-contact sensors to monitor the mechanical positions of the gripper and to assure that once a ham slice has been acquired, it is not lost during the transfer. A sensor will be used to verify that the ham slice has been ejected from the gripper prior to an attempt to acquire an additional ham slice.

2.5.4 Gripper solenoid valves and related wiring as well as sensor wiring will be enclosed in a stainless steel NEMA 4 box mounted to the second arm of the robot. This will protect the equipment and minimize wiring and pneumatic lines on the exterior of the robot arm.

2.5.5 Based on the information available from Adept Technology regarding the enhanced performance capabilities of the Adept HyperDrive equipment ordered with the robot, EwingGear™ Services believes that an average transfer cycle time of .75 seconds can be achieved. This would provide for a maximum production rate of 80 ham slices per minute.

2.5.6 Obviously, a two-position gripper could pick up two slices at a time. However, it would need to wait for the second slice to enter the pick point (or move to a different point), and it would need to have the ability to elevate the first slice above the conveyor to avoid interference while picking the second slice. Since short robot motions are not performed as rapidly as long moves, EwingGear™ Services is of the opinion that a dual position gripper would probably not increase thruput by more than 15% over a single slice gripper. Initially, it would also add considerably to the cost since it would have two distinct gripper mechanisms.

2.6 Mounted above the input end of the conveyor on a stainless steel structure will be the camera/lens assembly.

2.6.1 The camera/lens will be enclosed in a stainless steel NEMA 4 cabinet with a clear glass opening to provide a view of the conveyor belt by the camera/lens assembly. The glass viewing window will be sealed against the entrance of water and other contaminants by a food grade silicone rubber seal locked down with stainless steel fasteners.

2.6.2 The signal and power cables for this enclosure will exit from one of the vertical sides of the container so that there will be a minimum opportunity for penetration by water or other contaminants around the cable termination devices.

2.7 Our understanding is that the Panasonic CD40 camera to be furnished by Rutgers/CRAMTD has a programmable shutter capable of speeds up to 1/10,000 of a second. This will be adequately fast enough to stop the motion of the ham slice without the need to use a strobe light.

2.7.1 EwingGear™ Services does not anticipate the need for providing auxiliary lighting for the machine vision system as there will be relatively high contrast between the ham slices and the white surface of the conveyor belt. This will permit the machine vision system to operate with binary images rather than grey scale which should greatly simplify the machine vision software development time.

3.0 MACHINE VISION SOFTWARE

3.1 EwingGear™ Services will make full use of the Adept Technology machine vision software. This is a feature rich software package eminently suitable for this demanding production task. The software contains all of the necessary features to program the machine vision so as to acquire the ham slice, determine its centroid and orientation, send appropriate signals to the robot so as to orient the gripper and then direct the robot to acquire the ham slice as it moves along the conveyor belt.

3.1.1 Rutgers University will, of course, receive copies of both the source code as well as the compiled object code as a result of the software development work performed by EwingGear™ Services.

3.2 The software will be written to reject any slices which exceed a specified area as a means of rejecting overlapping slices. Rejected ham slices will be allowed to pass off the end of the conveyor for collection in a stainless steel container.

4.0 SAFETY DEVICES

4.1 The Adept robot and controller is equipped with software axis limit stops. The software limits will be used to restrict the working zone of the robot as one element of an integrated safety system. Specifically, the robots' first axis will be programmed to limit its motion to the minimum working envelope required to complete the task.

4.2 In addition to the emergency stop buttons located on the robot's teach pendant and the front panel of the robot control-

ler, EwingGear™ Services will provide an emergency stop button at each end of the ham slice conveyor.

4.3 The area immediately surrounding the robot's work zone will be guarded with clear polycarbonate plastic panels supported by aluminum structural supports. Removable panels to permit maintenance access to the equipment will be provided with electrical interlocks.

4.4 The customer is directed to refer to ANSI/RIA standard R15.06-1986, "American National Standard for Industrial Robots and Robot Systems - Safety Requirements" for recommended safeguarding procedures.

- - - - WARNING - - - -

TO AVOID INJURY TO PERSONNEL AND DAMAGE TO EQUIPMENT, ONLY PROPERLY TRAINED AND QUALIFIED PERSONNEL SHOULD BE ALLOWED TO OPERATE THIS EQUIPMENT.

O.S.H.A. COMPLIANCE

4.5 Compliance under Title 29, Chapter XVII, of U. S. Federal Regulations is strictly specified as being the responsibility of each employer (the purchaser). EwingGear™ Services, Inc. is vitally concerned about workplace safety and therefore endeavors to comply with the purposes and applicable standards of O.S.H.A., but the proposed equipment and quoted costs do not specifically include any costs for O.S.H.A. compliance because current O.S.H.A. regulations do not specifically address industrial robots.

4.6 In the event that the equipment proposed herein is found not in compliance with any future or proposed O.S.H.A. regulations, EwingGear™ Services, Inc. will endeavor to make such changes as may be required wherein technically feasible at the request of the customer and at the customer's expense.

4.7 It shall be the responsibility of the customer's safety engineers to carefully review the details of this proposal for conformance to O.S.H.A., state and company safety standards.

5.0 TRAINING AND ACCEPTANCE TESTING

5.1 EwingGear™ Services will provide two days system operation training during the acceptance runoff on our shop floor. This training will include general operational instruction for the PackOne robot and its controller, as well as instruction in the use of operation of the vision system equipment. Additional instruction in the operation of the conveyor and its controls as well as the operating characteristics of the special gripper will also be provided. Note that this training <u>will</u> <u>not</u> include training in the Adept Technology V+ robot programming language or the Adept machine vision programming language.

5.2 During the commissioning of the equipment at Rutgers/CRAMDT, EwingGear™ Services will provide an additional three days of system operation training for operating personnel.

5.3 Acceptance prior to shipment will be based on a mutually agreed upon procedure using simulated ham slices as well as some actual ham slices. Rutgers/CRAMDT will need to supply the sliced ham in some form of refrigeratable storage container so that slices could be used more than once. Note that an hour of production at 60 slices/min. would require approximately 790 lbs. of ham.

6.0 PRICING, DELIVERY & OPTIONS

6.1 Based on the foregoing technical descriptions and assumptions, EwingGear™ Services is privileged to provide its fixed price quotation for furnishing (1) Ham Slice Transfer System complete with robot and vision software, special gripper, conveyor and drive, robot support stand, camera/lens enclosure and stand, camera/lens enclosure and stand, documentation, demonstration, installation and acceptance runoff.

PRICE - - - - - - $ 56,635

6.2 The price is FOB your Piscataway, NJ facility, is exclusive of any applicable state or Federal taxes, is firm for 30 days, and is subject to escalation thereafter.

6.3 **DELIVERY** would be three to four weeks after receipt of the Adept PackOne robot and all its related equipment. Currently, delivery of the robot is scheduled for late October. If system acceptance is to be completed by the end of 1992, an order must be placed no later than 7Sept92.

OPTIONAL EQUIPMENT, which can be furnished, is as follows:

6.4 Optical encoder for conveyor tracking. This unit would be electrically/electronically compatible with the Adept A-Series MC controller. It would be enclosed in an aluminum housing, utilize stainless steel fasteners and have a watertight cable to the controller. It would be engineered and designed to meet USDA washdown requirements

\- - - - - - - $ 2,785

6.5 Adept Technology requires that the air used to pressurize the PackOne robot be dried to a dewpoint of 30-35°F. EwingGear™ Services is prepared to supply a refrigerated air dryer complete with automatic drain pre- and post-filters, electrical controls, etc. This unit would be sized to provide sufficient air flow for the entire system

\- - - - - - - $ 1,350

7.0 **WARRANTY**

7.1 All of the EwingGear™ Services engineered equipment and software will be warranted for one year or 3500 hours of use following acceptance. Service on this equipment will be EwingGear™ Services' responsibility. See attached EwingGear™ Services, Inc. standard warranty.

7.2 Non-warranty service work or special engineering services are available from EwingGear™ Services at a daily (weekday) rate of $600.00 based on an eight-hour day. Related travel and living expenses will be billed at cost plus a 10% surcharge.

EwingGear™ Services field engineering travel time will be billed at $36.00 per hour.

7.3 The Adept Technology robot controller and related hardware will be warranted, parts and labor, for a period of 12 months following acceptance at the customer site. In the last six months of the first year, the customer is charged for travel related expenses. During the warranty period, service on the Adept equipment will be carried out by Adept field service engineering from the local service office in Baltimore, MD.

DOCUMENTATION

8.0 The equipment will be shipped with two complete sets of documentation which will include user and maintenance manuals for the Ham Slice Transfer System. Two sets of documentation showing all commercial items as well as two sets of assembly drawings of custom-engineered items will be furnished. Complete electrical and pneumatic schematics will also be supplied. All EwingGear™ Services drawings will conform to the latest ANSI Y14.5 drafting standards. Construction of custom engineered machinery will conform to all applicable current J.I.C. industrial/electrical standards.

8.1 All electrical equipment will be constructed to meet applicable NEMA 4 requirements (watertight) as well as the applicable N.E.C. and F.M.A. industrial specifications. General purpose electrical control components will be Allen-Bradley unless otherwise specified by the customer.

9.0 It shall be the customer's responsibility to notify EwingGear™ Services of any prevailing local or regional construction or electrical codes and specifications which might apply to the construction of this system prior to final order placement.

10.0 Unless otherwise specified, all EwingGear™ Services equipment fabricated from low carbon steel will be primed and painted with a high-quality alkyd enamel industrial grade paint in EwingGear™ Services' standard machinery color, U.S. Federal Spec. #H7-565 (machinery beige).

11.0 Total system power requirement is as follows: 208/220V, 3 PH, 60 Hz, 5 KVA electric; 15 CFM @ 85 PSIG minimum compressed air.

CUSTOMER RESPONSIBILITIES

12.0 Unless otherwise agreed to in writing, the customer will be responsible for the following:

12.1 Dedicated manufacturing engineering and technical personnel to follow the project from inception;

12.2 General site preparation including the removal of any conflicting customer-owned equipment;

12.3 Rigging of system components into the job site from the customer's load dock;

12.4 Primary electric and pneumatic service to the installation, including a very low-impedance electrical earth ground;

12.5 Uniformity and consistency of workpiece quality;

12.6 Sufficient quantities of test parts and/or consumable materials for both initial and final testing;

12.7 Adequate time and access to the work area and the equipment to properly carry out the acceptance testing and commissioning work.

EWINGGEAR™ Services, Inc.

STANDARD WARRANTY

Seller warrants to buyer that products and any services furnished hereunder will be free from defects in material, workmanship and title and will be of kind and quality specified in Seller's quotation. The foregoing shall apply only to failures to meet said warranties (excluding any defects in title) which appear within one year from the date of initial operation or: 3500 hours of in-plant customer operation, whichever occurs first hereunder.

The conditions of any tests shall be mutually agreed upon and Seller shall be notified of, and may be represented at all tests that may be made. The warranties and remedies set forth herein are conditional upon (a) proper storage, installation, use and maintenance, and conformance with any applicable recommendations of Seller and (b) Buyer promptly notifying Seller of any defects and, if required, promptly making the product available for correction.

If any product or service fails to meet the foregoing warranties (except title), Seller shall thereupon correct any such failure either, at its option, (1) by repairing any defective or damaged part or parts of the products, or (2) by making available, F.O.B. Seller's plant or other point of shipment, any necessary repaired or replacement parts. Where a failure cannot be corrected by Seller's reasonable efforts, the parties will negotiate any equitable adjustment in price.

The preceding paragraph sets forth the exclusive remedies for claims (except as to title) based on defect in or failure of products or services, whether claim is in contract or tort (including negligence) and however instituted. Upon the expiration of warranty period, all such liability shall terminate.

The foregoing warranties are exclusive and in lieu of all other warranties, whether written, oral, implied or statutory. NO IMPLIED STATUTORY WARRANTY OF MERCHANTABILITY OR FITNESS FOR PARTICULAR PURPOSE SHALL APPLY. Seller does not warranty any products or services of others which buyer had designated.

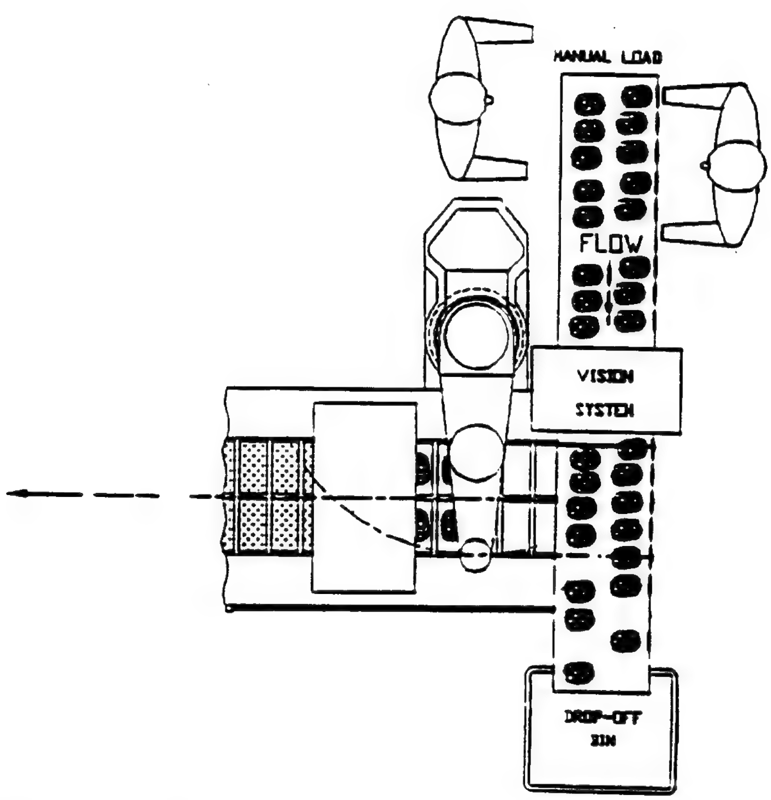
Combat Ration Advanced Manufacturing Technology Demonstration (CRAMTD)

Operation: Automated Filling Systems

Equipment: Robotic Filling of Placeables (Adept/EwingGear)

Characteristics/Advantages:

- Payload 13 pounds
- Maximum reach 31.5 inches
- Hyperdrive-cycle in 0.7 seconds for a distance of 28 inches
- USDA approved
- Vision system
- Flexibility by programming and changing end effector
- Production rate for ham slices - 60 per minute



Robot Demonstration Run

- 25 minutes @ 50 ham slices per minute
- Robot placed accurately 1250 ham slices into the MRE pouch

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Multicriteria Evaluation of Automated Filling Systems: A Case Study

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Abstract

Much has been written about the use of multiattribute decision models to evaluate manufacturing technologies. This article describes an application to a real problem using a recently developed multiattribute decision tool. The case study involves an evaluation of three candidate technologies for filling packaged food containers. A manual baseline filling method is compared with the two technology investment options of automated weigh filling and automated volumetric filling. In food industries, the cost of material overfill is important but is not the only factor that should be considered. A multiattribute decision model is formulated that considers difficult-to-quantify criteria, such as material conversion, information conversion, and strategic activities. For the given decision scenario, when only directly measurable annual cost savings are considered, the weigh filler option is preferred; however, when the additional criteria are considered, volumetric filling is preferred primarily due to its product and equipment flexibility. It is proposed that the methodology described here will enhance the acceptability of applying multiattribute decision making to manufacturing investment problems.

Keywords: *Multiattribute Decision Making, Decision Making, Manufacturing Investment, Automation, Food Processing*

Introduction

Much has been written about using multiattribute decision processes for the justification of advanced technology. This literature focuses on methodologies for combining financial criteria with nonfinancial criteria in a quantitative ranking process. The two principal approaches used are (1) multiattribute decision theory and (2) the analytic hierarchy process (AHP). A recent book by Canada and Sullivan[1] describes the use of these methods in capital budgeting analysis. Additional examples of the application of multiattribute decision theory can be found in References 1 and 2. Additional examples of the application of the AHP can be found in References 3 and 4.

Boucher and MacStravic[5] developed a methodology that combines easy-to-quantify and difficult-to-quantify benefits of new technology into a ranking of alternatives based on net present value. As in the case of the AHP, this method begins with a hierarchy, elicits pairwise comparisons among criteria, checks for internal consistency in the comparison matrix, and ranks alternatives. Unlike the AHP, this method makes the comparisons in a somewhat different manner, interprets the relative importance of different criteria in monetary terms, provides additional checks on the decision-maker's logic, and ranks alternatives in net present value terms. This methodology, termed nontraditional capital investment criteria (NCIC), has been implemented in microcomputer software[6] for routine evaluation of new technology projects. In this case study, we describe the application of this software for the evaluation of automatic filling technologies in the packaged food industry. This is an actual case study of technologies being proposed for a production system being designed and developed at the Rutgers University Center for Advanced Food Technology.

There are three steps in applying the multiattribute model we describe here. The first step is to design the framework of criteria that are important to consider. There is virtually nothing in the literature concerning how this should be done. We have proposed a standard format for doing this, which we will describe briefly.

The second step is to weigh and evaluate the criteria. This will be described using data collected from the system design engineers.

Finally, the evaluation of the decision-maker's logical consistency is required. Methods to determine the internal consistency of the decision-maker's judgment and the consistency of the judgments with principles of economic theory will be demonstrated.

Before discussing modeling issues, we will first describe the characteristics of the production process and the technology under consideration. This is the topic of the next section.

Technical Choice in Filling Operations

This study considered three methods for filling packaged food containers: manual methods, automated filling by volume, and automated filling by weight. Manual methods require that a worker deposit the ingredient into a container that is placed on a scale. When the appropriate weight is reached, the ingredients are then manually deposited into the food package on the production line. The package then moves through subsequent filling operations until all materials are added. Finally, the package is sealed.

The manual method is considered a baseline, because it is the least technologically advanced method of filling. The cycle times depend on the accuracy with which the worker tries to pre-weigh the material. This process is sometimes further specialized into having one worker group weighing materials while another worker group deposits materials into the food packages. *Figure 1*, view *a*, shows a production line organized in this way.

The second candidate filling technology controls ingredient fill by weight. Direct weighing of material can be performed in various ways. In its simplest implementation, a strain gage is mounted on a hopper, which is intermittently filled with material by a conveyor and emptied. A controller reads the strain gage and controls the filling of the hopper, stopping the filling operation when the hopper has reached a desired weight. The hopper is then opened and the material is dumped into the package. A more sophisticated approach to weigh filling is the combination scale. A combination scale has several hoppers to which ingredients are being fed by conveyor. Each hopper is equipped with a force sensor to measure weight and the ingredient flow into each hopper can be automatically controlled by controlling a baffle at its input. The controller that monitors hopper weight can be set so that each hopper will be filled to only a fraction of the total weight required to be dispensed into the package. For example, a hopper may be programmed to hold about a quarter of the material required in the package. There are several hoppers on a combination scale; for example, a scale may be designed with 16 hoppers. An algorithm in the controller of the combination scale reads the weight of each hopper and identifies a subset of hoppers, the combined weight of which is closest to the required package weight, while avoiding under fills. That subset of hoppers is simultaneously dumped into the package. The hoppers that were dumped are then refilled. A typical weigh filler installation is shown in *Figure 1*, view *b*.

In automated volumetric filling, a cup of a known size is automatically filled with the ingredient and the container is automatically dumped into the food package. There are different ways of implementing this filling method. The specific technique considered in this case uses cups of a known volume that move along a conveyor and through a rotating drum or tumbler that drops ingredients into the cup. The cup is conveyed from the tumbler to a dumping station where the ingredient is automatically deposited into the packages. *Figure 1*, view *c*, shows a production line serviced by such a volumetric filler. The cup filling operation is followed by an in-line check weigher. If cups are under the target weight for filling containers, the cups can be recycled through the tumbler as illustrated using the loop conveyor of *Figure 1(c)*. A volumetric filler is capable of very high speeds. The illustrated design has a throughput in excess of 400 fills per minute for small packages.

In general, the weigh filler is more accurate in deposited weights than volumetric methods, with the difference in accuracy increasing with increasing variability of density in the ingredient being handled. On the other hand, a machine of this technology tends to be slower than fillers based on the volumetric principle. In general, for a fixed amount of capital to invest, the tradeoff is accuracy versus speed as between a weigh filler versus a volumetric filler.

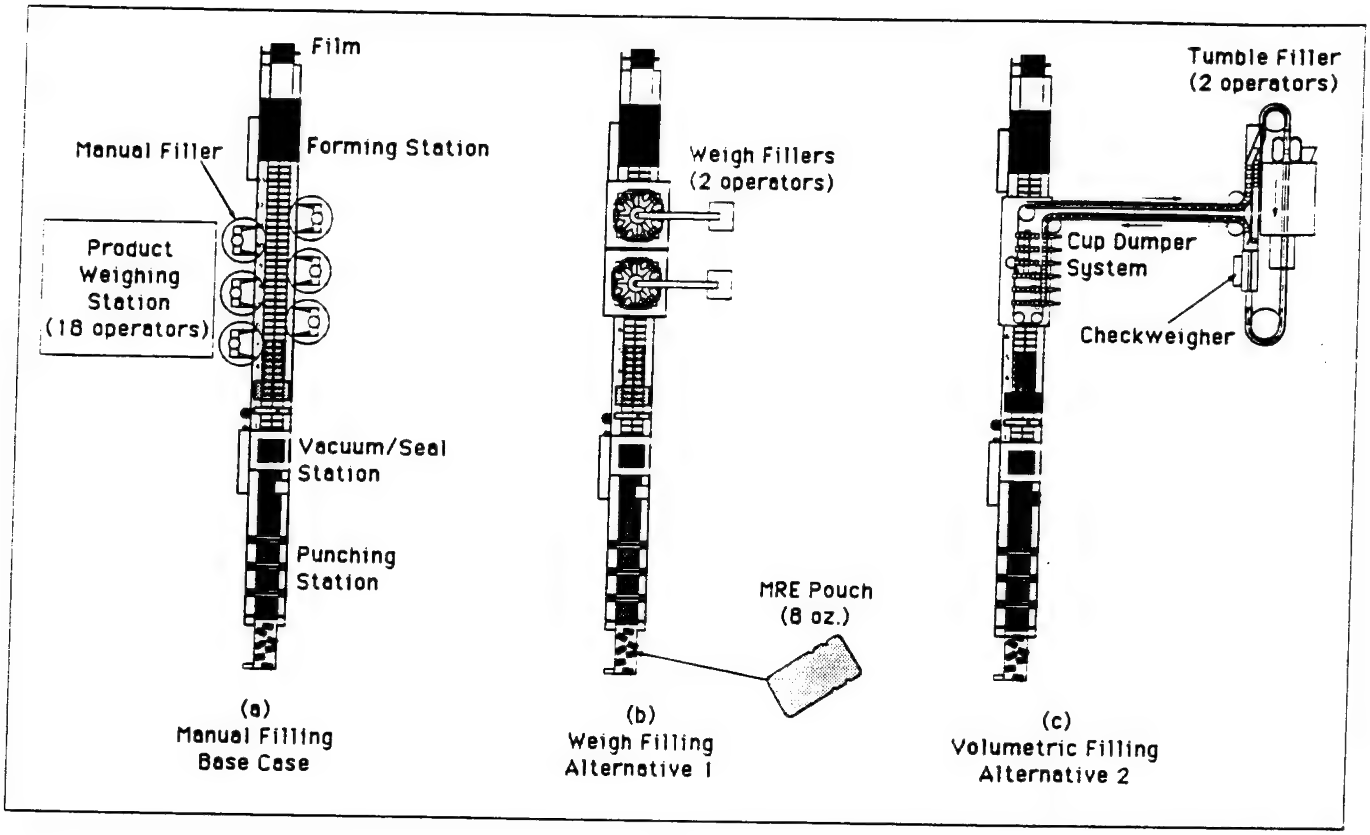


Figure 1
Horizontal Form-Fill-Seal Packaging Line—Filling Methods

Filling Accuracy and Material Cost

The relevance of accuracy in the economics of filling is the impact on material cost. *Figure 2* shows two distributions of container fill weights from two filling operations. A packaged food container has a lower limit on the weight of its contents. The daily production of containers (the production lot) is sampled, and the sample is tested for the occurrence of underweight packages. In the particular case being studied, the criterion is net drain weight. The drain weight of an ingredient in a package is determined by emptying the contents of the package and draining the liquids off the solid ingredient to be weighed. A package is found to be nonconforming if the weight of ingredients is below a lower limit. This can result in rejecting the production lot.

Given variance in the filling operation, resolving the problem of setting target fill weights involves trading off the risks of producing nonconforming units against the cost of material giveaway, or the overfilling of containers. *Figure 2* illustrates the

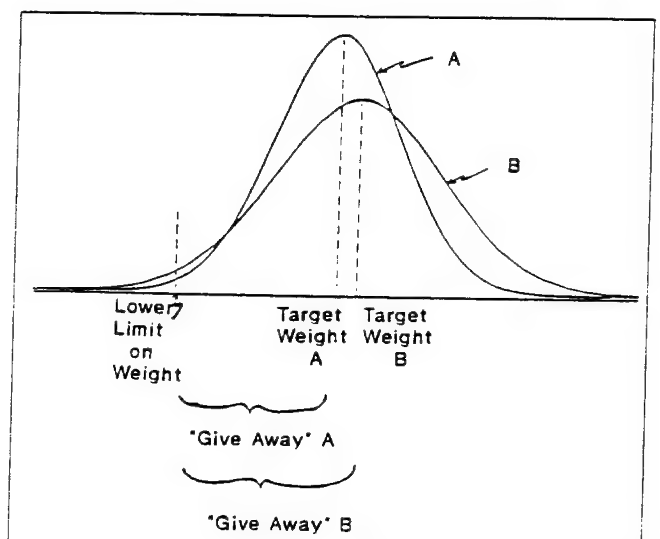


Figure 2
Comparison of Two Filling Weight Distributions

point. For the same level of protection against underfilling the container, the less accurate filling method requires more overfill, that is, the average

weight of material deposited per container will be greater in filling method B.

The problem of trading off overfill against the probability of nonconformance has been studied extensively.[7-9] Boucher and Jafari[10] have developed a model for acceptance sampling of total package weights, and Boucher, Jafari, and Luxhoj[11] have extended this model to the case of drain weights in the packaged food industry. These models were used in this study to compute ingredient cost savings for each technological alternative.

Framework for Classifying Nontraditional Capital Investment Criteria

The previous descriptions would indicate that, when comparing volumetric filling to weigh filling, an appropriate economic analysis would involve comparing savings in the cost of material giveaway for the more accurate filling method against the labor and capital cost saving of the higher speed method. Here we wish to expand on the criteria to consider in performing such an analysis and to describe a way of classifying those criteria.

The framework we are using reflects the way we think about production technology and production systems. Briefly, we consider a production system to be completely defined by three components: (1) the machine technology base, (2) the organization of production, and (3) the decision-making support structure. The machine technology base defines the conversion processes available to turn inputs into outputs. It represents an upper limit, or boundary, on the potential technical efficiency of the production line. The organization of production defines the way machines, workers, and material are organized along the product flow. The efficiency of factory organization will in part determine how well the factory achieves the upper limits of its technical efficiency. For the machinery of production and the organization of production to be effective, there must be a decision-making apparatus that determines, during any period of time, what products will be produced, how much will be produced, when materials will be ordered, what technical improvements will be made, and so on. This is the function of the decision-making support structure. When the three components above are completely specified, you have defined a production system.

Technical change in a production system (as opposed to a product design) occurs through a change in one or more of those three components: a new machine technology (for example, computer-controlled filler), a new organization of production (for example, cellular manufacturing), or a new decision-making technique (for example, computerized shop floor scheduling algorithm).

The reader is now referred to *Figure 3*, which is a pictorial illustration of the cause-and-effect relationships which underlie our framework. The two sets of ordered blocks on the left describe our view thus far: technical change takes place on one or more of the three system components.

We identify two major activities, the efficiency of which determine the overall economic efficiency of the enterprise: they are material conversion activities and information conversion activities. Material conversion activities are the physical processes that convert raw material to delivered final product. Information conversion activities convert raw data to decisions. Through a technical change in one or more of the three production system components, the performance effectiveness of material conversion or the performance effectiveness of information conversion or both can be changed. It is the changes in the performance effectiveness of these activities that may lead to reduced cost, increased revenue, or both. The changes in the performance of these activities are the effects of a change in the production system components.

Finally, economic outcomes are the consequences of the changes that occur in the performance of these activities. These outcomes may be immediate and direct, as in the case of labor efficiencies (operational), or distant and less direct, as in the case of improved market position from improved product quality (strategic).

In *Figure 4* we show the case for a computer-controlled ingredient filler with data logging capability. It is a technical change that occurs in the machine technology base. Its potential impact can be on the material conversion activities and, through its data logging capability, on information conversion activities.

We believe that the logical causal model just described is reasonable and consistent with our

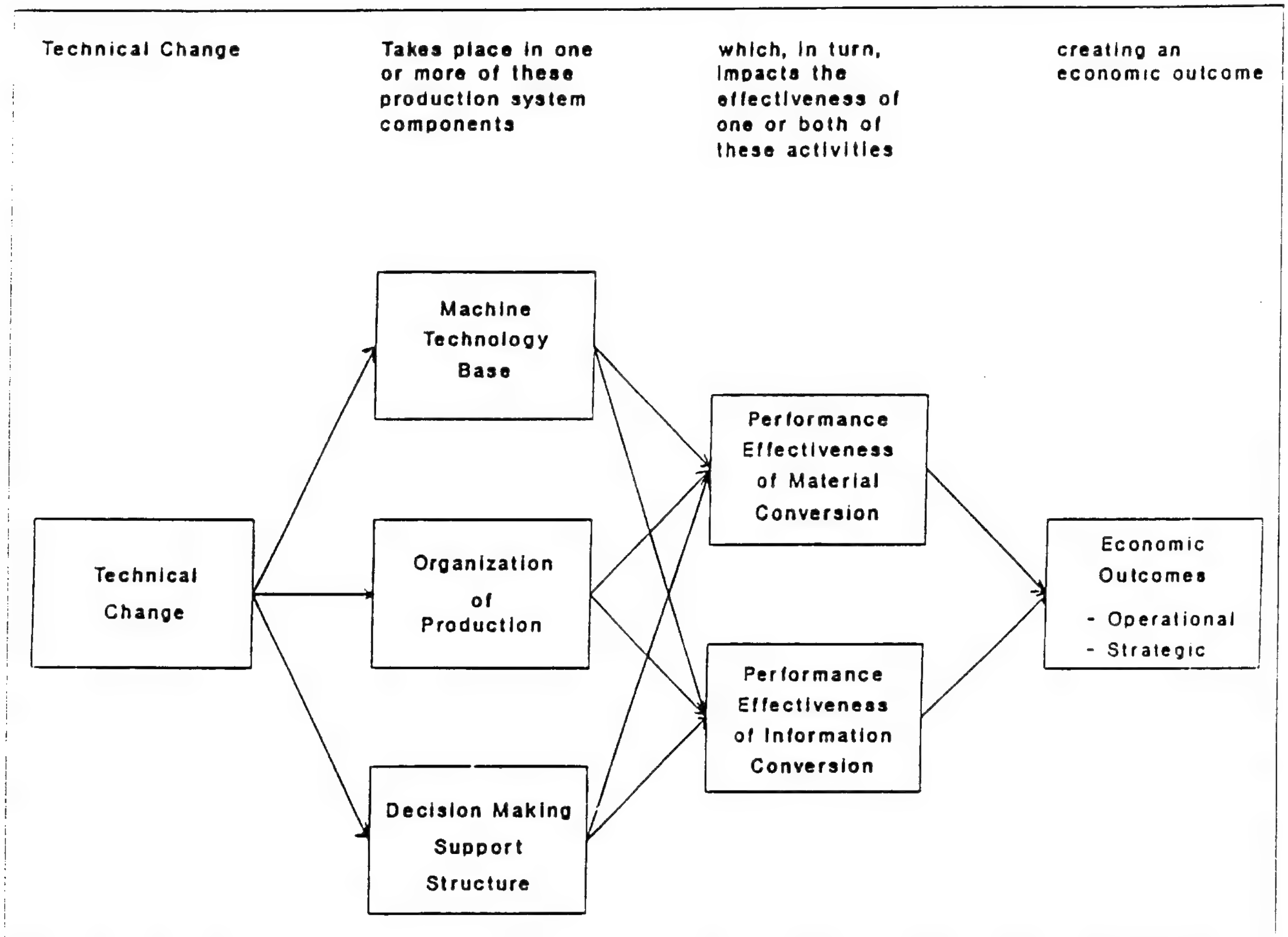


Figure 3
Model of the Relationship Between Technical Change and Economic Performance

experience. From this model we construct the decision-making framework for incorporating both traditional and nontraditional investment criteria.

The decision-making framework follows from *Figure 3*. The framework is produced by identifying all the important performance criteria affecting material conversion activities and information conversion activities that may change as a result of investment in the new technology and may have economic outcomes, even if the value of those outcomes is only vaguely understood at the time of the decision. *Figure 5* illustrates a few such criteria.

At the bottom of the hierarchy (level 3), we have the various performance criteria of the material conversion and information conversion activities (level 2). Our overall objective is at level 1. Given a proposed technical change, our objective is to compute the "value" of investing in that technology. If we know the dollar value of the effects of the change on the performance criteria at level 3, then we could sum these dollar values and the resulting total would be the overall value of the technical change. Unfortunately, we do not know all the dollar values at level 3.

The meaning of the criteria listed in *Figure 5* may not be obvious to the reader. The criteria Ingredient Savings refers to the pounds of ingredients saved by less overfill of packages. Labor Savings refers to the worker-hours that are displaced by the use of automatic filling methods. Equipment Flexibility refers to the ability to use the filler to fill different package types. Product Flexibility refers to the ability of the filler to handle different products (ingredients).

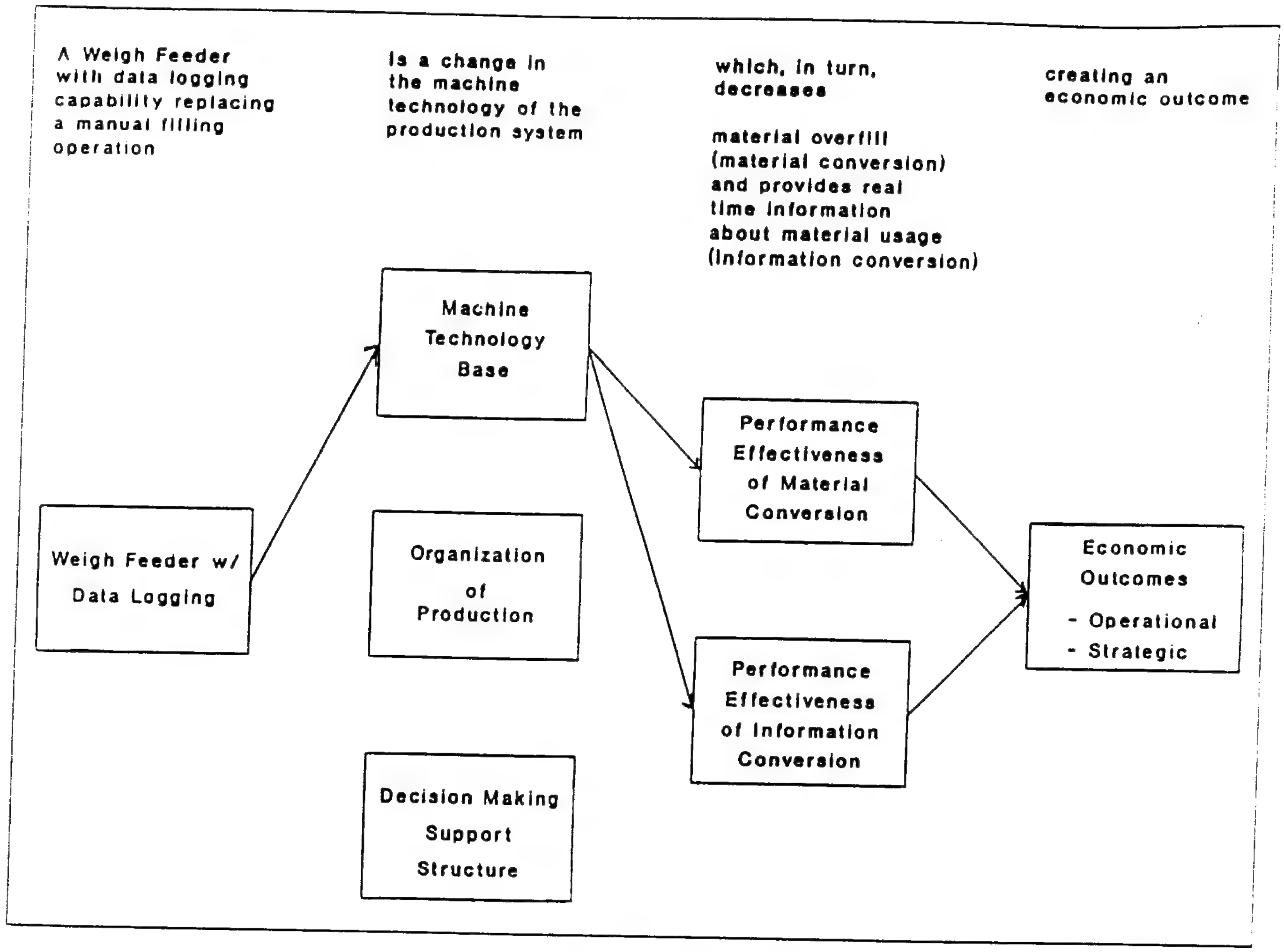


Figure 4
Weigh Feeding in Framework of *Figure 3*

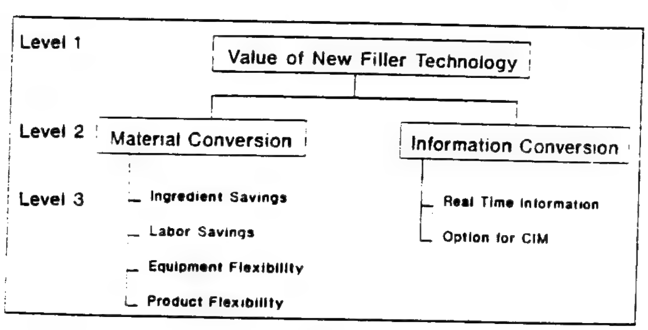


Figure 5
Examples of Material Conversion and Information Conversion Performance Criteria Having Value

Under Information Conversion, the criteria Real Time Information refers to the usefulness of having data on the weight deposited in a package available for use in decision making in real time. Option for CIM refers to the fact that automatic filling and data logging helps provide a basis for further computer integration. It is akin to having an option for future action and has a value analogous to buying an option on the futures market.

Referring again to *Figure 5*, it is obvious that certain criteria at level 3 can often be quantified. With respect to ingredient feeding operations, it is possible to compute a dollar value for ingredient savings and labor savings. This brings us to *Figure 6*. In *Figure 6* we have added another entity at level 2 entitled Annual Benefit. Here we lump the quantifiable dollar values of those changes in performance effectiveness that can be quantified in dollar terms. Consequently, we have removed Ingredient Savings and Labor Savings from under the entity Material Conversion. We have done this because

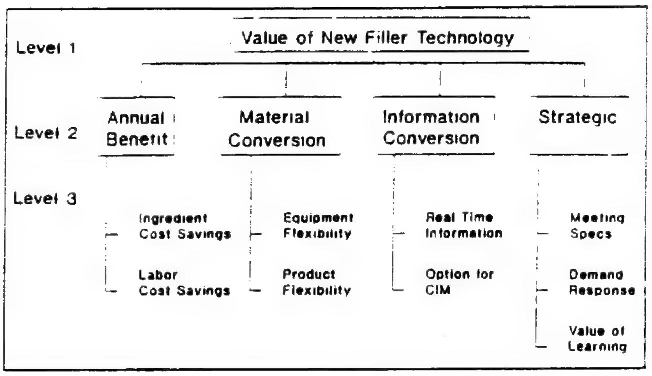


Figure 6
NCIC Decision-Making Framework

there is no reason to treat these categories as vague benefits: we can now measure their values in unambiguous terms.

Now we can make the following assertion about the process of capital investment analysis. Traditionally, when accountants, cost analysts, and engineers measure the value of an investment in production for capital justification purposes, the process implicitly followed is that of identifying as many criteria as possible on the right of *Figure 6* that could be moved to the left under the entity Annual Benefit. This would then be followed by using the value of those criteria under Annual Benefit to obtain the total value at level 1.

This process leaves behind the value of the criteria that could not be quantified, those under the other two performance categories. The value of these residual criteria are the factors that an experienced decision maker takes into consideration intuitively in the investment decision process. The three level 2 categories of Annual Benefit, Material Conversion, and Information Conversion can be generally called "operational" categories for improvement. There is another major area in which important criteria exist: this is the "strategic competitive criteria" shown on the right of *Figure 6*.

Strategic competitive criteria are the important factors that form the basis of competition in the industry. For the example of *Figure 6*, we have illustrated three: (1) Meeting Specs, (2) Demand Response, and (3) Value of Learning associated with the new technology. We will discuss the meaning of these criteria in a later section. Strategic criteria have economic value because they in part determine the long-term survivability of the firm in its market. Changes to the production system that improve company performance on strategic measures should be credited with the economic value that they create.

Ideas for technological change in production usually begin in corporate R&D, manufacturing engineering, or factory management. The perceived value of these ideas is often based on financial computations of obvious benefits versus investment cost. It is an unfortunate fact of life in many corporations that some important capital investment ideas never move to the level of serious consideration because the proposer is unable to meet the requirements of the corporate financial criteria. We assert that many profitable investment ideas never see the light of day because of the inability to quantify the economic value of nontraditional criteria. We later propose a new practice to replace traditional financial analysis in measuring economic value. In the next section we introduce a scenario that will provide the context to be used in illustrating this new practice.

Case Study in the Selection of Automatic Filling Systems to Replace Manual Methods

At any time, there exists a set of technical alternatives for a particular manufacturing function. One alternative may be technically superior to all other alternatives on one or more technical criteria: however, it is usually not the case that one alternative is economically superior to all other alternatives. The preferred technology is determined by the context in which the technology is to be applied. In effect, it is not possible to choose the economically appropriate technology without describing a decision scenario. In this section, we will describe a decision scenario created for this analysis.

In this decision scenario, the production facility described in *Figure 1(a)* is currently producing beef stew on two production lines using manual filling methods. The factory produces shelf-stable food in two distinct packages. A generic diagram of the processes involved is shown in *Figure 7*. There are four principal stages in the production process: cooking, product filling, packaging, and sterilization. Ingredients that require precooking, such as

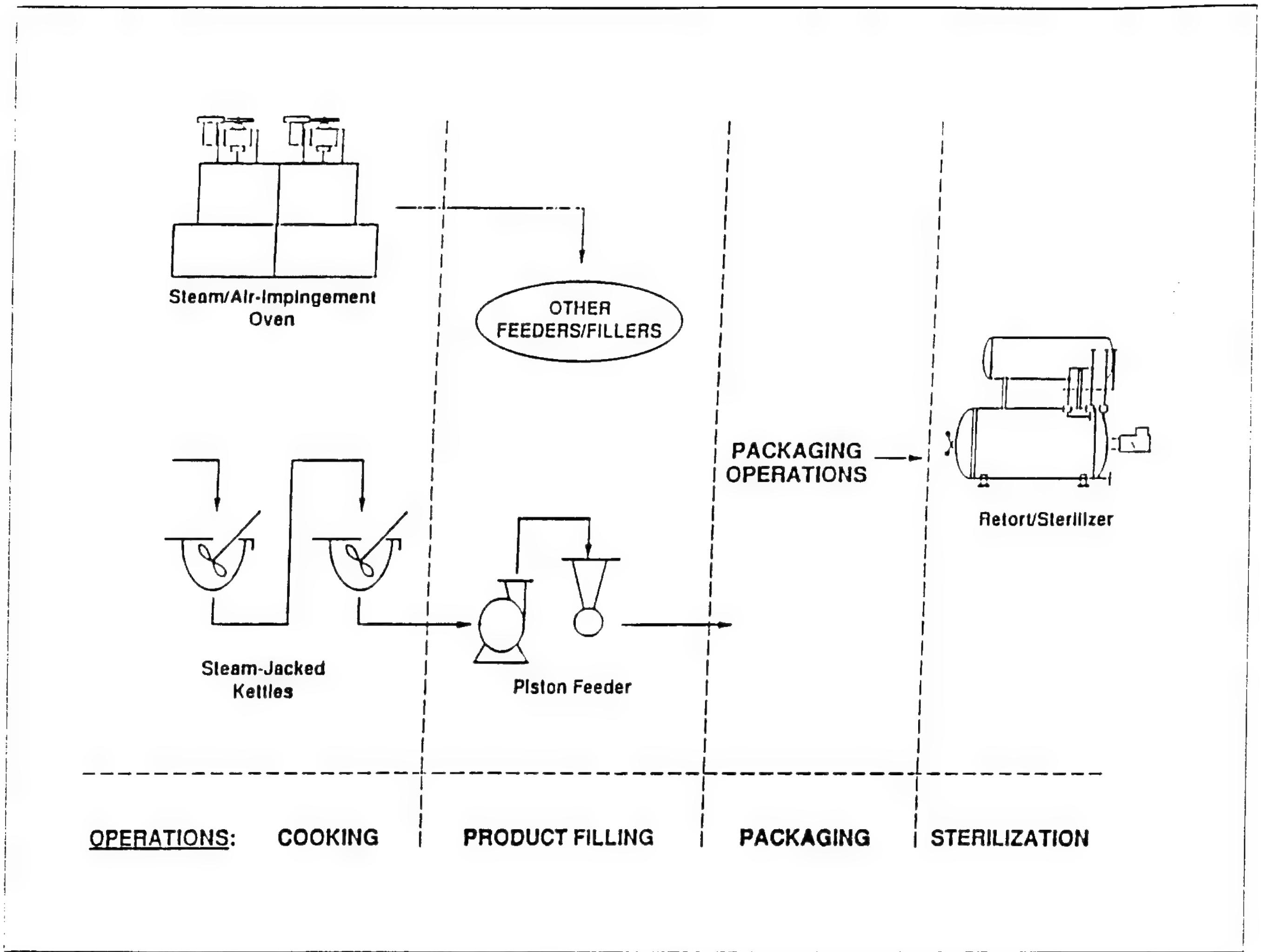


Figure 7
Processing Steps in Shelf-Stable Packaged Food Manufacture

meats and sauces, are prepared in kettles or ovens in the cooking stage. In the filling stage, materials are combined or filled into packages, which are then sealed in the packaging stage. Finally, the product is sterilized in the retort stage to kill any remaining microbial activity and render the package of product shelf stable and safe for consumption.

Figure 8 illustrates the two packaging lines. One line produces a 10 × 12" (25.4 × 30.5 cm) metal container that holds about 6 lb (2.7 kg) of food, referred to as a tray pack or half steam table tray. The other package is a flexible pouch that contains about 8 oz (227 g) of product. The government is the principal market for these products: the half steam table tray is used for field feeding of soldiers, and the pouch is an individual ration.

The manufacturer currently produces only in this market and obtains business through contract bidding. Current and projected contracts have established the annual volumes at 700,000 trays and 5,000,000 pouches, which is about 6 months of capacity on each packaging line. The manufacturer has specialized primarily in meat product, such as beef stew, but there is a variety of other products available for contract bidding.

The manufacturer is considering eliminating manual filling on the pouch line, which is extremely labor intensive, as shown in *Figure 1*, view *a*. Preliminary computations have been made for the volumetric and weigh filler concerning material and labor cost saving. The details of these computations appear in Appendix 1.

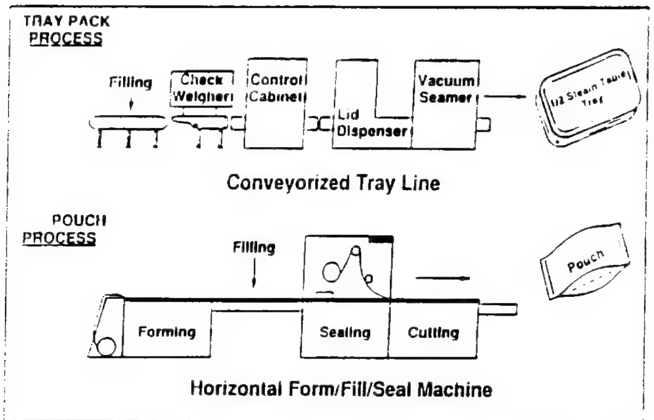


Figure 8
Two Packaging Operations

In the following sections, we introduce the method of nontraditional capital investment criteria (NCIC). We augment the ingredient and labor cost savings with additional criteria and incorporate them into the analysis.

Application of NCIC—Establishing Criteria

In this section we describe the methodology of NCIC and illustrate its application with our example case study. For a more thorough analysis of the methodology and its relationship to the AHP, the reader is referred to Reference 5. For information about the software developed for routine implementation of NCIC, see Reference 6. The decision process consists of four steps:

1. Identify the evaluation criteria and investment alternatives.
2. Make pairwise comparisons to determine the relative importance of criteria with respect to each alternative.
3. Evaluate judgmental inconsistencies from the pairwise comparison process.
4. Compute the present worth of each investment based on the value of traditional and nontraditional criteria.

Executing the first three steps required obtaining the testimony of experts knowledgeable about the technology, its benefits, and the particular circumstances of the decision scenario. A panel of two engineers responsible for the design of the filling/packaging system was formed for this purpose. Henceforth, we will refer to this panel as the Decision Maker (DM).

In Step 1, the evaluation criteria of *Figure 9* was developed in consultation with the DM. The two criteria identified under Annual Benefit, and calculated as shown in Appendix 1, were Ingredient Cost Savings and Labor Cost Savings. The criteria in the categories Material Conversion, Information Conversion, and Strategic are defined in Appendix 2.

In the latter three criteria, there is a significant difference between the technology being evaluated and the existing, manual (baseline) technology. We will touch on some of the important criteria here.

Under Material Conversion, Product Flexibility refers to the number of different products in the product mix that can be filled by each filling method. The existing product mix was defined as the products that were currently being produced and offered for bidding by the government contracting agency. For the baseline case, volumetric, and weigh fillers, the number of different products in the product mix were 13, 12, and 7, respectively. Thus, the volumetric filler could fill one less product type and the weigh filler could fill six less product types than the manual filling case. In effect, where product flexibility is concerned, the automatic filling operations are less flexible than manual (baseline) methods.

The category Equipment Flexibility is defined as the number of production lines that can be serviced by the filling methods. The weigh filler does not lend itself to being easily moved between production lines. The instrumentation involved requires a stable installation platform. When it is installed on the pouch line, it cannot be moved to the tray line without a major setup. Therefore, the criteria Equipment Flexibility is not considered with respect to the weigh filler or shown in the *Figure 9*, view *a*.

The volumetric filler is reconfigurable between production lines. The filler is on wheels and the conveyors are easily moved. Because the package size of the tray is larger than the pouch, larger cups are necessary to handle larger quantities of ingredient. The cups have been designed with adjustable bottoms to handle different fill sizes. Because equipment flexibility exists for the volumetric filler, it is considered in the framework of *Figure 9*, view *b*. Its benefit comes from the possibility of moving

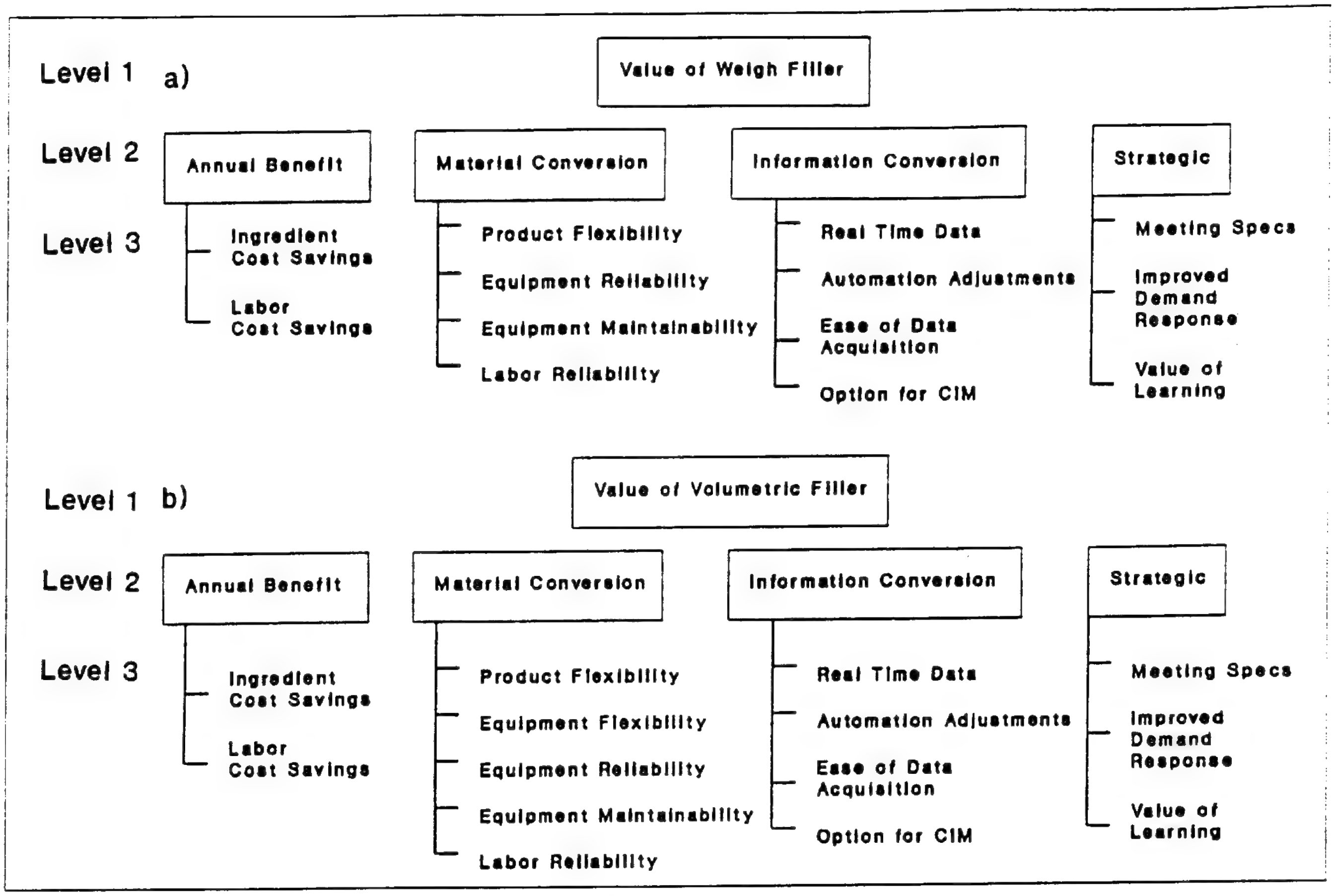


Figure 9
Evaluation Criteria for Weigh Filler (Alternative 1) and Volumetric Filler (Alternative 2)

the filler to the tray line when it is not running a contract on the pouch line.

The reader will note that product flexibility favors the manual method. It is, in fact, a penalty or cost incurred to go to automatic filling. Unlike some other multiattribute methods, NCIC handles both costs and benefits simultaneously in the evaluation process. The reader will also note, as in the case of equipment flexibility, that it is not necessary that the same criteria be included in the criteria list of all alternatives.

The two remaining criteria under Material Conversion are defined in Appendix 2. It is left to the reader to review these definitions.

The category Information Conversion contains criteria related to the value of enhanced data acquisition. Some of these concepts were discussed earlier. Again, the definitions appear in Appendix 2. Here we will comment only on the value of Real Time Data. For both the weigh filler and volumetric filler, information on ingredient weights are being automatically collected. The weigh filler has an onboard controller that records the weight dumped into the package; the check weigher in the conveying line of the volumetric filler has an onboard controller to record ingredient weights that subsequently are deposited into packages. The value of having this information is determined by the use to which it is put.

One can argue that, in the case of the volumetric filler system, the value of the check weigher is in determining which cups to dump into packages and which cups to recycle. In effect, its value is in better control of material giveaway, as calculated in Appendix 1; however, an important point to make in multicriteria analysis is that the criteria must be independent. The value of less giveaway has already been computed as Ingredient Cost Savings under Annual Benefit. To include it again would be double counting.

It is necessary to inform the decision maker that this independence must be strictly maintained in applying value to each criterion.

The DM determined that there were three important criteria in the Strategic category. They are defined in Appendix 1; here we will discuss only the criterion Meeting Specifications. This refers to the value of the enhanced ability to meet requirements for net weights and drain weights using automatic filling.

It is a common observation that the tedium of manual repetitious work in which measurement is involved will incur error. Under the scenario of this case study, which involved government contracts, meeting specifications is an important criteria for qualifying for future contracts. It is, in fact, a basis for the continued survival of the firm in this market.

Application of NCIC—Pairwise Comparisons

The second step in the process involves making pairwise comparisons among criteria. A meeting with the DM was separately scheduled to execute this step. The meeting lasted 4 hours, during which the decision makers were asked to make pairwise comparisons among criteria within each technology option. The comparisons were done by criteria category, for example, as shown in *Figure 10*.

Figure 10 is the completed comparison matrix for the weigh filler in comparing material conversion criteria. In each comparison matrix, the category Annual Benefit is included. By including this category, the comparisons are linked to dollar values.

There are three types of comparisons that can be made: comparisons of benefits with benefits, comparisons of benefits with penalties (costs), and comparisons of penalties with penalties. We will illustrate this using the matrix of *Figure 10*.

Two benefits in the comparison matrix of *Figure 10* are Annual Benefit and Labor Reliability. The annual benefit is the measurable dollar savings from material and labor; the labor reliability benefit comes from the reduction in labor absenteeism and turnover. Comparisons of this type involve questions such as: "By how much do you prefer $306,000 of annual benefit to the value of improved labor reliability associated with replacing manual

Material Conversion Activities: Weigh Filler

Benefit - Annual Benefit ($306,000)
Cost - Prod Flexibility (-6 No. of Products)
Cost - Equip Reliability
Cost - Equip Maintain
Benefit - Labor Reliability

Material Conversion	A	B	C	D	E
A - Annual Benefit	1	7	8	7	9
B - ProdFlexibility	1/7	1	7	7	7
C - EquipReliability	1/8	1/7	1	2	3
D - EquipMaintain	1/7	1/7	1/2	1	2
E - LaborReliability	1/9	1/7	1/3	1/2	1

Consistency Ratio = 0.135

Figure 10
Pairwise Comparison Matrix for Material Conversion Criteria Group—Weigh Filler

methods with a weigh filler?" (matrix cell A,E). The DM must supply a number from 1 to 9. This scale is adopted from the work of Saaty.[12] The answer of 9 naturally infers a ratio of 1/9th for the complementary matrix cell (E,A).

Comparing a benefit with a penalty is illustrated in cell (A,B). Comparisons of this type involve questions such as: "By how much do you prefer $306,000 of annual benefit to being able to retain the six products you are losing from your product mix by adopting the weigh filler?" The question, thus phrased, is asking for the opportunity value of the lost product. An answer of 7 indicates that the DM believes the annual benefit is seven times more important than the lost product.

Comparing a penalty with a penalty is illustrated in cell (B,D). This involves comparisons between the loss in product flexibility and the unknown cost of equipment maintainability that comes from replacing manual filling with the proposed automated filling system. Comparisons of this type involve questions such as: "What is the relative cost of the loss of six products in the product mix to the cost of equipment maintainability that will result from replacing manual filling with a weigh filler?" A value of 7 implies a judgment that B will be seven times more costly than D.

Appendix 3 shows the final form of all of the comparison matrixes for this study. These matrixes of judgments are now used for further analysis.

Application of NCIC— Judgmental Inconsistency

Two forms of inconsistency are investigated. The first is inconsistency due to violating the laws of transitivity. Simply stated, if A is valued twice as high as B and B is valued twice as high as C, then A must be valued four times as high as C. May[13] asserts that intransitivity may not be a consequence of judgmental error, but rather it may be a natural phenomenon. The application of the maximum eigenvalue method and the computation of a consistency ratio (CR) for a comparison matrix was introduced by Saaty[12] in the context of the AHP. Saaty develops a concept of "tolerable inconsistency." He recommends that a CR of 0.1 or less be considered consistent; a ratio greater than 0.1 shows inconsistencies. This is simply a guideline. The value of the consistency ratio for *Figure 10* is shown below the chart. Five comparison matrixes show consistency ratios above 0.1.

Lane and Verdini[14] have noted a special case in which inconsistencies cannot be avoided. This occurs when the ratio scale being used is not robust enough to account for the differences between the most important and least important criteria. For example, if Annual Benefits is 20 times more important than Labor Reliability, this cannot be stated using the ratios 1 through 9. There is strong evidence that this phenomenon has occurred in this case study.

Inconsistency is observable in human judgment (Brown and Lindley[15] and von Winterfeldt and Edwards[16]). When it is encountered in NCIC, the DM must first reconsider the matrix of judgments. This may lead to a new set of more consistent values; however, it may also lead to a conclusion that the inconsistency is not easily resolvable. This is particularly true when the DM is more than one individual making a consensus judgment.

However, as Saaty concludes, "Clearly there are times when the individual cannot make a clear decision because the tradeoffs among several activities come out to be the same. There is no reason why not acting is any less desirable than acting if the criteria are faithfully identified and evaluated."[12]

During data collection, the DM should be given every opportunity to resolve problems of inconsistency by reevaluating the answers given in the pairwise comparisons. If inconsistency cannot be resolved during reevaluation, the data should be allowed to stand. NCIC, like the AHP, allows for inconsistency to occur. Inconsistency will be covered more later.

Application of NCIC— Computing the Criteria Weights

The completed pairwise comparison matrixes are used to calculate the relative weights of criteria. The normalized eigenvector method is used for this calculation, the same procedure as employed by the AHP for the assessment of weights. This procedure is reviewed in Boucher and MacStravic.[5] Let us define:

W_{ik} = the relative value (weight) of criterion k for alternative i

AB_{ik} = the annual benefit of criterion k for alternative i

AB_{io} = the calculated annual cost savings of alternative i, labeled Annual Benefit in the comparison matrix

then,

$$AB_{ik} = AB_{io}\,(W_{ik}/W_{io})$$

where W_{io} is the relative weight of the annual benefit criterion.

In this manner, the implied annual benefit of each performance criterion is calculated. It is the sum of the implied annual benefit of performance criteria combined with the calculated annual cost savings that yields the total annual benefit of an investment alternative. Let

TAB_i = total annual benefit of alternative i

$$TAB_i = \sum_k AB_{ik}$$

Using this method, the difficult-to-quantify benefits have been quantified in dollar terms and can be included in determining the total value of an investment alternative.

For the case study, the results of computing the eigenvalue weights and computing annual benefits from those weights is given in *Table 1*. A summary of these values by category is given in *Table 2*.

From *Table 2* some general observations can be made. When only directly measurable annual cost savings are considered, the weigh filler option has an advantage of $45,000. When the additional criteria are considered, the volumetric filler has a $186,000 advantage. The difference is primarily due to the relative inflexibility of the weigh filler, as indicated in *Table 1*. The product inflexibility of the weigh filler has added a cost of $106,000 more than the volumetric. The equipment flexibility of the volumetric filler has given it a benefit of $114,000 over the weigh filler. These two categories have swung the comparison dramatically in favor of the volumetric filler. This is the general conclusion to be drawn from the NCIC analysis of this case.

Table 1
Annual Benefit of Individual Criteria

	Weigh Filler	Volumetric Filler
Annual Benefit	$ 306,000	$ 261,000
Prod Flexibility	-120,000	-14,000
Equip Reliability	-33,000	-24,000
Equip Maintain	-24,000	-30,000
Labor Reliability	16,000	29,000
Equip Flexibility	-0-	114,000
Real Time Info.	81,000	90,000
Option for CIM	24,000	23,000
Data Acquisition	45,000	41,000
Auto Adjustment	16,000	11,000
Meeting Specs	93,000	91,000
Demand Response	22,000	21,000
Value of Learning	20,000	19,000
Totals	446,000	632,000

Table 2
Annual Benefit by Criteria Weight

	Weigh Filler	Volumetric Filler
Annual Benefit	$ 306,000	$261,000
Material Conversion	-161,000	75,000
Information Conversion	166,000	165,000
Strategic	135,000	131,000
	446,000	632,000

At this point, NCIC provides another consistency check. This was mentioned earlier as a check of returns to scale. Three terms are used by economists in referring to the incremental value associated with an incremental unit of an input factor of production. They are: decreasing returns to scale, constant returns to scale, and increasing returns to scale. These cases are illustrated in *Figure 11*, views *a-c*. *Figure 11*, view *d*, illustrates an illogical relationship, economically speaking. Here a higher level of the performance yields less value than a lower level. Here we generalize these concepts to the benefits and penalties analysis in NCIC.

When a criterion is quantified in some unit of measure, and there are two or more alternatives in the comparison, the criterion can be checked for implied returns to scale. In this case study, consider product flexibility. As previously discussed, when compared to manual methods, there are six less products that can be filled by the weigh filler and one less product for the volumetric filler.

This results in quantified values of -6 and -1 for weigh filler and volumetric, respectively. From *Table 1*, we note corresponding costs of $-120,000 and $-14,000 from the analysis. This implies a value of $21,000 per unit for the first five units and

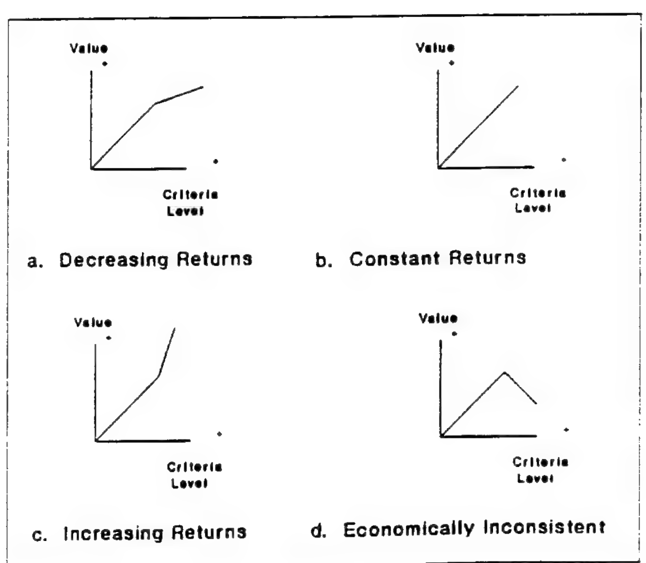


Figure 11
Returns to Scale

$14,000 per unit for the next unit. This is shown graphically in *Figure 12*, which is an output of the NCIC software. This is a case of decreasing returns to scale. It is not out of line with economic theory. The appropriateness of the result should be given consideration by the DM, who is forced to return to the judgment matrix if the returns to scale graph is illogical.

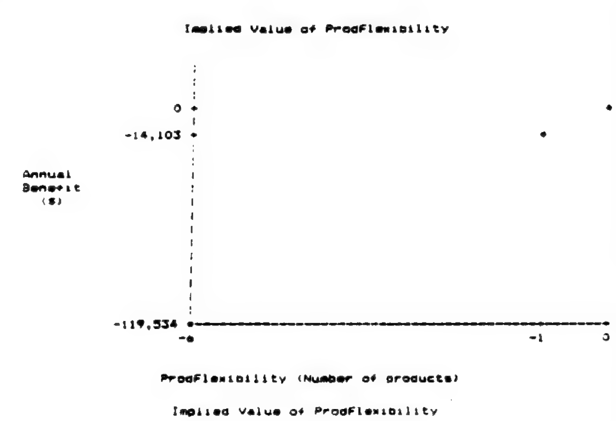
Application of NCIC—Computing Net Present Values

Using the total annual benefits of $446,000 for the weigh filler and $632,000 for the volumetric filler, the next step is the calculation of present worth. *Figure 13* shows the screen used to enter capital costs for each alternative, the tax rate and depreciation schedule, and the time horizon and discount rates determined by company policy. When there is considerable difference in risk between investment alternatives, NCIC software allows the user to input different (risk-adjusted) discount rates.

Figure 14 is the final output of the analysis. *Figure 14*, view *a*, is a comparison of net present value for each alternative when only considering the directly measurable annual cost savings. Both alternatives qualify on this basis and the comparison is quite close. *Figure 14*, view *b*, is a comparison of net present value for each alternative when one considers both the directly measurable annual cost savings and the annual benefits implied for the performance criteria. Both options improve their position; however, the superiority of the volumetric filler for this decision scenario is clearly shown.

Post-Auditing the Analysis—Decision-Maker's Judgments Revisited

NCIC is an evolving process of analysis. We are in the process of implementing a structured post-audit procedure to assess the overall validity of results generated by NCIC. The purpose of the post-audit is to evaluate reasonableness of results and to use findings to refine the NCIC data collection process. We have already described tests of internal consistency (the consistency ratio) and tests of consistency with economic theory (returns to scale). Here we are concerned with assessing validity of an outcome overall.



Your judgments imply decreasing returns to scale for this criteria.

Range of Units	Dollars / Unit
-6.00 to -1	21,086.15
-1.00 to 0	14,103.05

Figure 12
Returns to Scale for Product Flexibility as Implied from DM Judgments

	Present Worth Analysis	
	Alt. 1	Alt. 2
Marginal Tax Rate (%) (State and Federal)	38.0 %	38.0 %
Discount Rate (%)	12.0 %	12.0 %
Time Horizon (years)	8 yrs.	8 yrs.
Depreciation Amounts:		
	Year 1 - 100,000	Year 1 - 62,500
	2 - 85,720	2 - 53,576
	3 - 61,240	3 - 38,276
	4 - 43,720	4 - 27,324
	5 - 35,000	5 - 21,874
	6 - 34,960	6 - 21,850
	7 - 35,000	7 - 21,874
	8 - 4,360	8 - 2,726
Total Investment	$ 400,000	$ 250,000

Note: Based on Asset Class 20.4 and MACRS Table 2 (IRS Publication 534, Depreciation)

Figure 13
NCIC Present Worth Analysis

The first test in the post-audit is to determine whether the NCIC derived rankings are at least rank ordered with the DM's perception of the criteria most heavily influential in the analysis. A follow-up session was held with the two participating design engineers.

They were asked to separately rank each nonfinancial criteria within its criterion group. The DMs had not been provided with the final outcome of the session in which they had provided a consensus judgment in the pairwise comparison process. This represented a sort of "holistic" judgment by the DM within a class. Their individual rankings were averaged and a summary ranking is provided in *Table 3*. Ties are given the same rank.

In general, the outcome was not surprising. The criteria evaluated as most important by NCIC were evaluated at the top of their group in the post-audit; however, a significant data point appears out of line within the Information Conversion group, where Automation Adjustments ranked higher in post-audit than it did in NCIC.

In another post-audit test, the DMs were asked to indicate which of the two alternatives—weigh filler or volumetric—were preferred on the basis of each criteria. In *Table 4*, their responses appear in the post-audit column. The NCIC column shows the rankings as indicated by NCIC. With the exception of Real Time Data, the most important criteria in terms of their overall significance are in line with the holistic post-audit judgments. For NCIC, alternatives were considered essentially equivalent on a criteria if their values were within 10% of each other.

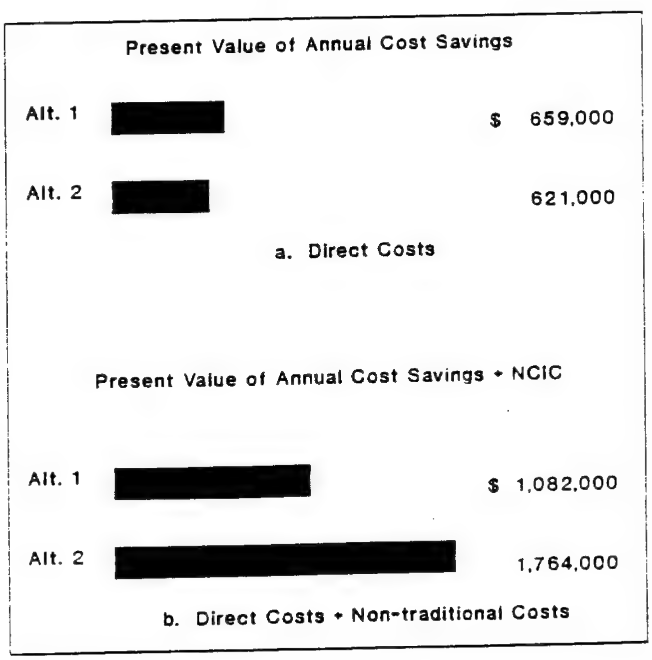


Figure 14
Net Present Value of Alternatives

Table 3
Post-Audit of Criteria Rank Within Category Groups

	Post Audit	NCIC
Material Conversion Group		
Product Flexibility	1	$ -134,000
Equipment Flexibility	1	114,000
Equipment Reliability	3	-57,000
Equipment Maintainability	4	-54,000
Labor Reliability	5	45,000
Information Conversion Group		
Real Time Data	1	171,000
Automation Adjustments	2	27,000
Ease of Data Acquisition	3	86,000
Option for CIM	4	47,000
Strategic Group		
Meeting Specifications	1	184,000
Improved Demand Response	2	43,000
Value of Learning	3	39,000

Table 4
Post-Audit of Preferred Alternatives with Respect to Criteria

	Preferred Alternative	
	Post Audit	NCIC
Material Conversion Group		
Equipment Flexibility	volumetric	volumetric
Product Flexibility	Volumetric	volumetric
Equipment Reliability	volumetric	volumetric
Equipment Maintainability	volumetric	weigh •
Labor Reliability	equal	volumetric •
Information Conversion Group		
Real Time Data	weigh	volumetric •
Automation Adjustments	weigh	weigh
Ease of Data Acquisition	equal	equal
Option for CIM	weigh	equal •
Strategic Group		
Meeting Specifications	equal	equal
Improved Demand Response	equal	equal
Value of Learning	weigh	equal •

• Not in Agreement
Equal means within 10% of each other

Holistic rank order judgments are considered to be fairly easy for people to make. Difficulties arise when individuals are asked for cardinality relationships, as in NCIC. The fact that the output of NCIC and holistic rank order judgments are in reasonable relationship with one another in *Tables 4* and *5* says very little given the scant data; however, the results are encouraging. Repetition of this experiment on other case studies will provide more evidence.

The most important question to address in post-audit is the reasonableness of the numbers themselves. What is the basis for the implied dollar values attributed to the difficult-to-quantify criteria?

There are three ways in which a criteria can generate economic value or cause economic cost. The first is to directly add or subtract from cost. For example, in replacing manual filling with automatic equipment, the performance criteria Equipment Maintainability directly adds to cost. On the other hand, the performance category Labor Reliability obtains its value by direct reduction of costs of absenteeism, turnover, and retraining. Referring to *Table 5*, both of these criteria are indicated as having their economic benefit (penalty) directly related to impact on cost.

A second way of creating value is through pricing. This can occur, for example, if the product is not in a commodity market and is distinguished from competitor products through, for example, superior quality. Hence, in the case of a technical change that yields a criterion Improved Quality, that criterion may very well obtain its value through improved pricing. There are no examples of that in *Table 5*.

Table 5
Sources of Economic Value for Difficult-to-Quantify Criteria

	Operational	Strategic	
Criteria	Cost Reduction or Increase	Pricing	Market Share (Volume)
1. Product Flexibility			x
2. Eqpt. Flexibility	x		
3. Eqpt. Reliability	x		
4. Eqpt. Maintainability	x		
5. Labor Reliability	x		
6. Real Time Information	x		
7. Option for CIM	x		
8. Data Acquisition	x		
9. Auto Adjustments	x		
10. Meeting Specs	x		x
11. Demand Response			x
12. Value of Learning	x		

A third way of creating value is through improvements in market share (volume). As volume increases, the increased contribution margin will generally translate directly into improvements in cash flow. As shown in *Table 5*, Product Flexibility, Meeting Specs, and Demand Response were considered to obtain their value through improvements in market share relative to what the market share would be if the investment in automated filling were not made.

Having identified the proposed sources of value, it is useful to analyze the reasonableness of the numbers generated by NCIC. Here, for illustration, we will look at the two most important criteria in differentiating between the two alternatives: Product Flexibility and Equipment Flexibility.

As previously described, choosing a weigh filler reduces the potential products on which the company may bid from 13 to 7. If the company would never be inclined to bid on these products, then the cost of losing them from the product mix is 0; however, were the company to want to bid on those products in the future, the cost of losing them from the product mix today is the discounted future cash flow from the foregone contribution margin.

Based on a census of manufacturing industry data, it is not unreasonable to assume a contribution margin of \$0.50 per pouch. For a contract of 400,000 pouches, this would contribute \$200,000 in cash flow to the firm. In effect, if the company were to forego an average of 400,000 units by reducing its potential market by 46%, the implied values for this criteria would be justified. Under these circumstances, an annual loss of \$120,000 for reduced product flexibility, as shown in *Table 1*, does not seem unreasonable.

In the case of equipment flexibility, we refer to the additional benefits that are made possible by being able to relocate the volumetric filler to the tray line when it is not employed on the pouch line. This layout is depicted in *Figure 15*. These benefits certainly include material and labor cost savings in the production of tray products; however, it should also include the value of nontraditional criteria in relation to tray production, for example, labor reliability and meeting specifications. If you count only material and labor cost savings, our estimates indicate that it would be necessary to use the volumetric filler to produce somewhat in excess of

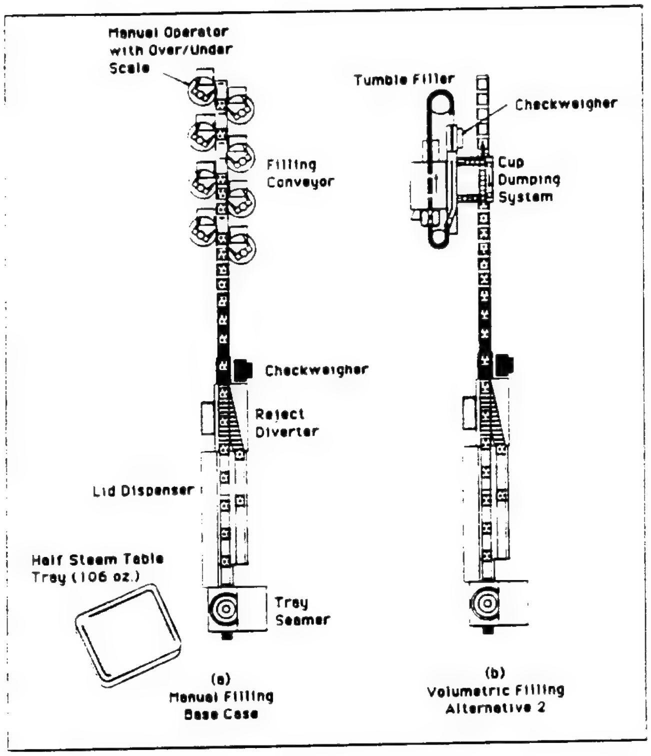


Figure 15
Tray Pack Line—Filling Methods

700,000 units to realize $114,000 in benefits. Given the current contract volume of 700,000 units, it is not reasonable to expect the benefits to come from this source alone. It would be necessary to include the additional benefits of nontraditional factors on the tray pack product line to reach this level of benefit.

Post-Auditing the Analysis—Sensitivity Test by Forcing Consistency

It was noted earlier that we observed the effect of the 1-9 scale in forcing some inconsistency in the pairwise comparison matrix. There is a method of "forcing consistency" that is described in Saaty[12] and that is used in the AutoMan[17] decision support system. This method uses the comparison values in the first row of a matrix to derive the perfectly consistent values for the remaining comparisons. The underlying assumption is that the DM has the most confidence in the first row of comparisons. A consistent comparison value is found by computing the ratio of the first-row value for the current column criterion to the first-row value for the current-row criterion.

For example, from Appendix 3 observe that the comparison matrix for Material Conversion Activities for the weigh filler alternative has a consistency ratio of 0.135, which suggests inconsistency (> 0.10). By using the method described in AutoMan, the consistent value for comparing product flexibility to equipment reliability is 1.14 (= 8/7), which is the value from comparing annual benefit to equipment reliability divided by the value from comparing annual benefit to product flexibility. This value is then rounded down to 1.0 when placed in the matrix of comparisons.

After forcing consistency, the revised consistency ratios (CRs) for the pairwise comparison matrixes are computed as:

	Weigh Filler		Volumetric Filler	
Matrix	CR_{old}	CR_{new}	CR_{old}	CR_{new}
Material Conversion	.135	.071	.121	.095
Information Conversion	.089	.089	.158	.099
Strategic	.132	.069	.126	.065

For original matrixes with consistency ratios greater than 0.10, the method described above is used to develop "tolerable inconsistencies."

Revised tables for Annual Benefit of Individual Criteria and for Criteria Group Summary are exhibited in Appendix 4. When tax rates, depreciation, and investment cost are added, the present worth computation is as follows:

	Annual Benefits	Present Worth AB + NCIC
Weigh Filler	$649,801	$1,117,943
Volumetric	$620,711	$1,651,173

Note that forcing consistency using the method described in AutoMan does not change the overall result of the analysis (that is, the volumetric filler is preferred in the multiattribute analysis). Prior to an NCIC analysis, the weigh filler is the preferred technology. Using the original inconsistent comparison matrixes, the difference in the present worths for the two alternatives after an NCIC analysis is

682,000. After forcing consistency, this difference between the present worths is $533,230 for a reduction of $148,770. The final recommendation of using the volumetric filler as the preferred technology remains the same. The inconsistencies in some of the matrixes led to an inflation of the aggregate benefits for the volumetric filler, and deflated the benefits for the weigh filler; however, the filler recommendation after forcing consistency is the same as with inconsistencies present in the matrixes. Thus, the judgmental inconsistencies in this case study appear "tolerable."

These observations represent another way in which the evaluation of the DM judgments can be performed in post-audit. Just as initial comparisons among criteria are made in the context of the company's situation, so also is any post-audit evaluation subject to the same conditions.

Concluding Remarks

This case study was undertaken to illustrate the NCIC process applied to a problem in the food industry. The method outlined may also be applied to discrete parts manufacturing. We illustrated the main steps of the economic evaluation process: (1) develop the criteria framework, (2) elicit pairwise comparisons among criteria, (3) evaluate consistency of judgments, (4) compute present worth of alternatives. The main objective of NCIC is to provide a decision-making process that includes difficult-to-quantify criteria in the analysis while addressing the typical requirements of the corporate budgeting process, which is to provide justification in terms of corporate financial goals.

The case study analysis of filling systems using NCIC concluded that volumetric filling with in-line check weighing is the preferred solution for the given decision scenario. When only directly measurable annual cost savings are considered, the weigh filler has an advantage of $45,000. When the additional difficult-to-quantify criteria of material conversion, information conversion, and strategic activities are considered, the volumetric filler has a $186,000 advantage. This is primarily due to differences in product flexibility and equipment flexibility between volumetric and weigh filling. The equipment flexibility of the volumetric filler, for instance, produces a benefit of $114,000 over the weigh filler. Both methods are shown to be superior to manual filling. These are not general conclusions, but are specific to the case scenario as described.

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Appendix 1—Method of Computing Material and Labor Cost Savings

Material Cost Savings

A filling process is defined by a random variable, X, the quantity of material deposited in an individual container. A lower limit, L, is imposed on the average drain weight, $\overline{W}$, of the material.

$$\overline{W} = X - Y = X - kX = (1 - k)X$$

where

Y = the process loss beyond filling
k = the mean percent loss in the process, independent of X

Production lots of size N are evaluated for minimum average drain weight by taking a sample of size n. Let μ_X be the expected value or target value of the fill weight. Relying on the central limit theorem, we assume that $\overline{W}$ is normally distributed with mean $\mu_{\overline{W}}$ and standard deviation $\sigma_{\overline{W}}$. Further,

$$\mu_{\overline{W}} = (1-k)\mu_X$$

$$\sigma_{\overline{W}} = \frac{\sigma_W}{\sqrt{n}} = \sqrt{\frac{\sigma_x^2 + \sigma_y^2 - \rho\sigma_x\sigma_y}{n}}$$

where σ_Y is the variance of the process loss, independent of μ_X, and ρ is the correlation between X and Y. We note

$$Pr(\overline{W} < L) = \int_{-\infty}^{L} f(\overline{W}) = \Phi\left(\frac{\mu_{\overline{W}} - L}{\sigma_{\overline{W}}}\right)$$

where $\Phi(z)$ denotes the cumulative distribution for the standard normal. The sterilization process loss, Y, is normally distributed with $k = 0.2152$; $\sigma_Y = 0.22869$. Furthermore, an evaluation of correlation between X and Y showed $\rho = 0$.

Observations of industry practice and experiments have indicated the following standard deviations of a fill for the various filling methods under consideration:

Filling Method	σ_X, oz (g)
Volumetric	0.095 (2.7)
Weigh	0.06 (1.7)
Manual	0.167 (4.7)

Filling Method	μ_X, oz (g)
Volumetric	3.50 (99)
Weigh	3.45 (98)
Manual	3.63 (103)

The target values for the various filling operations are summarized below:

Filling Method	Target Fill Weights Based on μ, oz (g)	L, oz (g)
Volumetric	3.27 (93)	3.50 (99)*
Weigh	3.26 (92)	3.45 (98)*
Manual	3.30 (94)	3.63 (103)*

*Dominant target value

The quality control specifications for the beef ingredient require that both the lower limit on sample average drained weight, μ, and the lower limit on the drained weight for the ingredients in an individual pouch, L, must be exceeded. For this condition to hold, the target fill weight must be set equal to the greater of the two values in the above

table for each respective filling method. These binding or dominant target fill weights are so identified.

In the decision scenario, an annual production volume of 5,000,000 pouches is assumed. At that production level, the total annual fill weight of beef is then computed for each filling method. These values are:

Filling Method	Annual Volume	Total Annual Fill Weight, lb (kg)
Volumetric	5,000,000	1,093,750 (496,125)
Weigh		1,078,125 (489,037)
Manual		1,134,375 (514,552)

The fill weight savings in beef over the manual filling method is calculated for both the volumetric and weigh filling methods. These material savings are 40,625 lb (18,427.5 kg) and 56,250 lb (25,515 kg), respectively, for volumetric and weigh filling. Using a value of $2.88/lb for the semiprocessed beef ingredient, the material cost savings in beef over the manual filling method is then calculated for both volumetric and weigh filling at an expected annual production volume of 5,000,000 pouches. These material cost savings are:

Filling Method	Material Cost Savings
Volumetric	$117,000
Weigh	$162,000

These values are then used in the NCIC analysis.

Labor Cost Savings

Manual Filling

For manual filling, 24 workers are assumed (6 dumping ingredients and 18 weighing) to achieve a production rate of 102 pouches/min. At an assumed annual production volume of 5,000,000 pouches, there are:

$$\frac{5{,}000{,}000 \text{ pouches}}{102 \text{ pouches/min}} = 817 \text{ hours}$$

Thus, 817 hours × 24 workers = 19,608 worker-hours are required to achieve the desired annual production volume for the assumed production rate.

Volumetric Filling

For volumetric filling two workers are assumed (1 loading and 1 machine operator). As with manual filling with an assumed annual production volume of 5,000,000 pouches there are 817 hours.

Thus, 817 hours × 2 workers = 1634 worker-hours are required.

Weigh Filling

For weigh filling the production rate is 66 pouches/min per machine. Therefore, two machines are required to achieve an effective rate of 102 pouches/min. Using the concept of machine coupling, it is assumed that two workers are sufficient to load and operate both machines. For an annual production volume of 5,000,000 pouches, there are 817 hours as in the previous two cases.

Therefore, 817 hours × 2 workers = 1634 worker-hours are required for weigh filling.

Using an assumed labor rate of $8.00/hr that includes fringe benefits, annual labor cost savings are calculated for the volumetric and weigh filling alternatives with respect to the baseline case of manual filling. These annual labor cost savings are:

Volumetric Filling: (19,608–1634 hr) × $8.00/hr = $143,792

Weigh Filling: (19,608–1634 hr) × $8.00/hr = $143,792

Appendix 2—Criteria Definitions

We have identified many important performance criteria by which the investment alternatives may be evaluated. They are described below:

1. *Annual Labor Cost Savings*—The computed cost savings resulting from reduced direct and indirect labor.
2. *Annual Material Cost Savings*—The computed cost savings resulting from reduced material usage.
3. *Product Flexibility*—The number of different products that can be filled by equipment.
4. *Equipment Flexibility*—The number of production lines that could be serviced by the filling method.
5. *Equipment Reliability*—Mean time to failure (MTTF) for equipment.
6. *Equipment Maintainability*—Cost to maintain equipment.

7. *Labor Reliability*—The degree to which absenteeism and turnover of the labor force disrupts production.
8. *Real Time Data*—The ability to capture and store production information within seconds of its occurrence. Includes the value of improved timeliness of data.
9. *Option for CIM*—The degree to which a particular alternative provides a basis for higher level computer integration.
10. *Ease of Data Acquisition*—Improvements in the ability to acquire data automatically. Includes the reduction in staff to gather data and the accuracy of the data for decision making.
11. *Automatic Adjustments*—The degree to which automatic parameter adjustments and software revisions can be made to equipment.
12. *Meeting Specifications*—The percentage of conforming units.
13. *Improved Demand Response*—The maximum level of production that can be achieved in the short run.
14. *Net Value of Learning Experience with New Technology*—When a new technology is implemented by a company, the engineers, managers, and workers become acquainted with using this technology. This puts the individuals in a position where they can more easily adopt future technologies that build on the technology currently being considered. There is a value to the company in so positioning itself. However, there are training costs associated with the adoption of a new technology. This criterion should be thought of as the benefits minus the training costs or the "net value" of the learning experience with a new technology.

Appendix 3—Pairwise Comparison Matrixes for the Case Study

Comparison Matrixes for Weigh Filler Alternative

Material Conversion Activities:
Benefit–Annual Benefit ($305,792)
Cost –ProdFlexibility (-6 Number of products)
Cost –EquipReliability
Cost –EquipMaintain
Benefit–Labor Reliability

Material Conv.	A	B	C	D	E
A–Annual Benefit	1	7	8	7	9
B–ProdFlexibility	1/7	1	7	7	7
C–EquipReliability	1/8	1/7	1	2	3
D–EquipMaintain	1/7	1/7	1/2	1	2
E–Labor Reliability	1/9	1/7	1/3	1/2	1

Consistency Ratio = 0.135

Information Conversion Activities:
Benefit–Annual Benefit ($305,792)
Benefit–Real Time Info
Benefit–Option for CIM
Benefit–Data Acquisition
Benefit–Auto Adjustmment

Information Conv.	A	B	C	D	E
A–Annual Benefit	1	8	8	8	9
B–Real Time Info	1/8	1	4	2	8
C–Option for CIM	1/8	1/4	1	1/3	2
D–Data Acquisition	1/8	1/2	3	1	3
E–Auto Adjustments	1/9	1/8	1/2	1/3	1

Consistency Ratio = 0.089

Strategic Activities:
Benefit–Annual Benefit ($305,792)
Benefit–Meeting Specs
Benefit–Demand Response
Benefit–Value of Learning

Strategic	A	B	C	D
A–Annual Benefit	1	7	9	9
B–Meeting Specs	1/7	1	5	8
C–Demand Response	1/9	1/5	1	1
D–Value of Learning	1/9	1/8	1	1

Consistency Ratio = 0.132

Comparison Matrixes for Volumetric Alternative

Material Conversion Activities:
Benefit–Annual Benefit ($260,792)
Cost –ProdFlexibility (-1 Number of products)
Benefit–EquipFlexibility
Cost –EquipReliability
Cost –EquipMaintain
Benefit–Labor Reliability

Material Conv.	A	B	C	D	E	F
A–Annual Benefit	1	9	6	8	8	9
B–ProdFlexibility	1/9	1	1/4	1/3	1/3	1/5
C–EquipFlexibility	1/6	4	1	6	6	8
D–EquipReliability	1/8	3	1/6	1	1/2	1
E–EquipMaintain	1/8	3	1/6	2	1	1
F–Labor Reliability	1/9	5	1/8	1	1	1
Consistency Ratio = 0.121						

Information Conversion Activities:
Benefit–Annual Benefit ($260,792)
Benefit–Real Time Info
Benefit–Option for CIM
Benefit–Data Acquisition
Benefit–Auto Adjustments

Information Conv.	A	B	C	D	E
A–Annual Benefit	1	7	9	7	9
B–Real Time Info	1/7	1	7	3	9
C–Option for CIM	1/9	1/7	1	1/3	5
D–Data Acquisition	1/7	1/3	3	1	5
E–Auto Adjustments	1/9	1/9	1/5	1/5	1
Consistency Ratio = 0.158					

Strategic Activities:
Benefit–Annual Benefit ($260,792)
Benefit–Meeting Specs
Benefit–Demand Response
Benefit–Value of Learning

Strategic	A	B	C	D
A–Annual Benefit	1	6	8	8
B–Meeting Specs	1/6	1	5	8
C–Demand Response	1/8	1/5	1	1
D–Value of Learning	1/8	1/8	1	1
Consistency Ratio = 0.126				

Appendix 4—Annual Benefit of Individual Criteria and Criteria Group Summary After Forcing Consistency

Alternative 1 (Alt. 1)–Weigh Filler
Alternative 2 (Alt. 2)–Volumetric Filler

Annual Benefit of Individual Criteria

	Alt. 1	Alt. 2
Annual Benefit	$ 305,792	$ 260,792
ProdFlexibility	−62,374	−13,972
EquipReliability	−54,681	−25,348
EquipMaintain	−39,593	−31,605
Labor Reliability	18,745	36,084
EquipFlexibility	0	91,907
Real Time Info	80,547	74,335
Option for CIM	24,044	16,031
Data Acquisition	45,272	52,059
Auto Adjustments	16,171	14,320
Meeting Specs	70,273	68,722
Demand Response	24,279	23,553
Value of Learning	29,314	28,487
Totals	$ 457,789	$ 595,365

Criteria Group Summary

	Alt. 1	Alt. 2
Measurable Annual Cost Savings	$ 305,792	$260,792
Material Conversion Activities	−137,903	57,066
Information Conversion Activities	166,034	156,745
Strategic Activities	123,866	120,762
Totals	$ 457,789	$595,365